

DIVISION 700 - MATERIALS AND TESTS

700.01--General. Materials will be inspected and sampled in accordance with current Department SOP pertaining to inspecting and sampling.

Unless otherwise provided, all materials furnished which are to remain in place after final acceptance shall be new and unused before incorporation into the work, except that crushed reclaimed concrete pavement meeting the requirements of Section 703, as amended, may be used to produce aggregate for all hot mix asphalt pavements. When allowed by the specifications, Recycled Asphalt Pavement (RAP) may be used in the manufacture of hot mix asphalt pavements. Other recycled products approved for use by the Department may be incorporated in the work.

The Contractor shall maintain sufficient approved materials on hand so that delays to the work will not result from the necessary sampling, testing, and evaluation of test results.

Domestic steel, iron and wire products including prestressing cable and strand shall be furnished for incorporation in the work. All manufacturing processes, including application of a coating, for these materials must occur domestically. However, pig iron and processed, pelletized, and reduced iron ore manufactured outside of the United States may be used in the domestic manufacturing process for steel and/or iron products. For the purpose of this specification, the activity of coating is considered a manufacturing process. The material being applied as a coating is not covered under Buy America. Coating includes all processes which protect or enhance the value of the material to which the coating is applied, such as epoxy coatings, galvanizing, painting, etc.

Domestic shall be understood to mean all States of the United States, District of Columbia, Puerto Rico, American Samoa, Guam, the Virgin Islands and any other place subject to the jurisdiction of the United States.

In the case of coatings for the above referenced domestic steel, iron and wire products, it shall be the Contractor's responsibility to forward to the State Materials Engineer a certified statement from those having applied a coating to these materials that the application of the coating occurred domestically.

It shall be Contractor's responsibility to forward to the State Materials Engineer such acceptable certification from the manufacturer, or at the election of the State Materials Engineer, such certification may be acceptable directly from a manufacturer annually, or more often, when requested by the State Materials Engineer.

700.02--Glossary of Terms and Definitions.

Aggregate - Inert material such as sand, gravel, lightweight aggregates, broken stone, slag, shell, or combinations thereof.

Argillaceous - Containing or consisting of clay.

Asphaltic Cement - A product of the refining of crude oil to form a residue which is used usually without the addition of more than a small quantity of flux or any liquefying agent of a higher volatile material than the residue itself.

Calcareous Material - A material containing more than 50 percent calcium type material.

Cementitious Material - Portland cement, or blend of portland cement and pozzolan material used as the bonding agent in portland cement concrete. Cementitious shall mean "as having cementing properties".

Clay - The fraction of a soil finer than 0.005 mm that is more or less plastic when wet.

Compaction - The process of obtaining the density of a soil or material.

Crusher Run - The product of a crushing plant that has not been rescreened or separated into various sizes.

Cutback Asphalt - An asphaltic material obtained from the refining of petroleum by adding to or fluxing the residue from distillation with volatile petroleum fractions to produce a uniform mixture which is capable of becoming quite fluid at relatively low temperatures.

Fineness Modulus - An empirical factor obtained by adding the total percentages of aggregate retained on the Nos. 100, 50, 30, 16, 8, 4, 3/8", 3/4", 1 1/2", and 3" sieves and dividing the sum by 100.

Frame - The part of the work or materials for which the same quality characteristics are specified, such as a base course, an aggregate stockpile, a hot bituminous pavement course, etc.

Gravel - The granular, pebbly material, usually retained on a No. 8 sieve, resulting from the natural disintegration of rock.

Increment - The smallest unit(s) set aside for the sampling and testing process.

Loess - Wind-blown, yellowish-brown loam having little or no stratification.

Lot - A subdivision of a frame, representing a designated quantity of work or materials, and is the unit of such work or materials which will be accepted or

rejected.

Liquid Limit (LL) - The water content, expressed in percentage by weight of the oven-dried soil, at which the soil passes from a plastic to a liquid state when subjected to a standard method of determining liquid limit of soils.

Mechanical Analysis - The determination of the size and grading of soil particles by standard tests.

Optimum Moisture - The moisture content necessary to obtain the standard density of a soil.

Overburden - Refers to soil or similar material directly above a deposit of rock, sand, gravel, or select material.

Pea Gravel - That portion of uncrushed gravel passing a 3/8 inch sieve and retained on a No. 8 sieve.

Plastic Limit (PL) - The water content, expressed in percentage by weight of the oven-dried soil, at which a soil passes from a solid or semi-solid state to a plastic state when subjected to a standard method of determining plastic limit of soils.

Plasticity Index (PI) - The range of water content through which the soil remains in a plastic condition. This term is the numerical difference between the liquid limit and plastic limit and is a measure of cohesion.

Portland Cement Concrete - A concrete mixture composed of cementitious materials, water, fine aggregate, coarse aggregate and possibly admixture(s).

Sample - The portion taken from a lot and considered to represent the whole or a designated portion of the lot. It may consist of one or more increments or a fractional part of one or more combined increments.

Sand - A fine granular material resulting from the natural or mechanical disintegration of rock. Depending on its use, material may be classed as sand if it passes the 3/8 inch, No. 4 or No. 10 sieve.

Sand Clay - A mixture of sand and clay often found blended so that their opposite qualities tend to maintain a condition of stability under varying moisture contents.

Screenings - Broken rock, limestone, slag, or other material, including the dust, of a size that will pass a 1/2 inch sieve.

Selected Material - Material from State-furnished or optioned sources, for use in bases, or for other specified use.

Shale - A fissile rock formed by the consolidation of clay, mud, or silt having a finely stratified or laminated structure.

Shrinkage Limit (SL) - The maximum calculated water content of a soil at which a reduction in water content will not cause a decrease in the volume of the soil mass.

Sieves - Sieves for testing purposes conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes of the AASHTO Designation: M 92.

Silt - The finer particles of organic or rock substance, ranging in size from 0.05 mm to 0.005 mm.

Slag - The nonmetallic product thrown off from molten ore or metal or other processes and used as fine or coarse aggregate.

Soil - A natural aggregate of mineral grains, with or without organic constituents, that can be separated by gentle mechanical means such as agitation in water.

Spall - A relatively small piece or fragment broken from rock, concrete, or other material.

Specific Gravity - The ratio of the weight of a volume of some substance to the weight of an equal volume of substance, usually water, taken as a standard or unit.

Standard Density (Standard Compaction) - The maximum dry unit weight in pounds per cubic foot obtained by the compactive effort exerted under the applicable test designation as provided in Subsection 700.03.

Sublot - The smallest unit(s) set aside from a lot for the sampling and testing process.

Test Portion - The actual quantity of material tested which may be, in some instances, the whole of the sample or, in other instances, only a quartered or other portion of the sample.

Test Result - The value of the specified characteristic obtained from testing a single test portion.

Test Value - The value determined as being the test result when only one test is required to satisfy a specified condition, or the average of the test results on two or more test portions of a lot, or a designated portion thereof.

Volume Change (VC) - The decrease in volume of the soil mass when the water

content is reduced from a given percentage to the shrinkage limit.

Water-Cement Ratio - The ratio of the weight of water used, including free moisture in the aggregate, to the weight of cementitious material.

Other Definitions - Other applicable definitions as prepared by the Special Committee on Nomenclature and adopted by AASHTO.

700.03--Sampling and Testing. Sampling and testing for acceptance and control of materials may be performed at any time prior to incorporation in the work. Sampling and testing for control and acceptance of a work item will be performed progressively as sections of the work item are being constructed or completed, as applicable.

Unless otherwise designated, all tests will be made in accordance with applicable standard methods of AASHTO, ASTM, Federal Specifications, or approved Mississippi Test Methods (MT-_____) in effect on the date of advertisement for bids. Note: It is contemplated that certain methods of testing will be developed by the Department. These will generally consist of minor revisions of AASHTO or ASTM Methods and will be designed to more nearly fit local conditions. Such methods are designated MT-_____. As such methods are developed, approved, and issued, they will be used as standards in field testing or in the Central Laboratory, as designated in the method, on projects advertised subsequent to their approval and issuance.

Material requiring specified tests used by a plant for producing composite material(s) or product(s) to be used in the work will be tested and approved by the Engineer. If such materials, composite materials, or products are stored separately for the exclusive use in the work, the cost of testing will be borne by the Department. If such materials, composite materials or products are not stored separately for the exclusive use in the work, the cost of testing shall be borne as set out in the Department's issued SOP in effect at the time bids are received.

700.04--Determination of Conformity. The determination of conformity with each required measurable characteristic under the intent of Subsection 105.03 will be made in accordance with the following:

All test values or test results used to determine compliance will be rounded off to the nearest decimal point as expressed in the specifications for the particular characteristic under consideration. Fractions beyond the point of rounding amounting to less than 0.50 will be dropped. Similar fractions amounting to more than 0.50 will be rounded off by increasing the last digit within the rounding. Similar fractions amounting to even 0.50 will be rounded toward the specifications by dropping or by increasing the last digit within the rounding, as applicable.

The various frames of materials or work will be divided into lots as specified in the contract or conforming to the Department's SOP for frequency of sampling and testing.

In the case of borderline quality products or a demonstrated trend toward borderline quality products, the Engineer will require the Contractor to improve the quality of the materials or work to more nearly conform to the specifications and may require a suspension of the operations which have resulted in the borderline product or the trend toward borderline quality until such corrective measures have been taken as deemed necessary to produce the contemplated quality products.

All increments of tests for determination of acceptance will be taken by random sampling. However, during or as a result of visual inspection, the Engineer will take increments for testing for progress checks or spot checks at any time and place the Engineer may deem necessary to determine weak spots or other progress information. The results of any such progress or spot checks may be used to determine whether or not additional work or corrective action is considered necessary prior to acceptance testing.

Minimum and maximum requirements in these specifications are set out on the basis that the desirable average test value of the materials or work is appreciably above the minimum requirement or appreciably below the maximum requirement established.

700.05--Material Certifications and Certified Test Reports. All certifications and certified test reports shall meet the requirements set forth herein except certification requirements for cement and asphalt are set out separately in Department SOP TMD-21-01-00-000 and TMD-22-01-00-000.

700.05.1--Certifications. All certifications shall:

- (a) Have letterhead of the manufacturer, producer, supplier, or fabricator.
- (b) Include the project number.
- (c) Itemized list of materials covered by the certification.
- (d) Contain a material conformance statement which certifies that the materials conform to the specific specification requirements. Example: I/We hereby certify the materials listed herein conform to the requirements of Subsection 714.14 of the Mississippi Standard Specifications for Road and Bridge Construction.
- (e) Certification for all iron, steel and steel wire products must also include a certified statement by the manufacturer that all of the manufacturing

processes, excluding those for pig iron and processed, pelletized, and reduced iron ore used in the manufacture of said steel and/or iron products, have occurred domestically.

(f) Signature of a responsible company official.

700.05.2--Certified Test Reports. All certified test reports shall:

- (a) Have letterhead of the manufacturer, producer, supplier, fabricator, or laboratory.
- (b) Include name and description of material, lot, batch or heat number, etc., as applicable.
- (c) Show results of each required test, and state that the test was run according to the test method specified.
- (d) Test reports for all iron, steel and steel wire products must also include a certified statement by the manufacturer that all of the manufacturing processes, excluding those for pig iron and processed, pelletized, and reduced iron ore used in the manufacture of said steel and/or iron products, have occurred domestically.
- (e) Signature of the responsible laboratory official.

SECTION 701 - HYDRAULIC CEMENT

701.01--General. The following requirements shall be applicable to hydraulic cement:

Different brands of cement, or the same brand of cement from different mills, shall not be mixed or used alternately in any one class of construction or structure, without written permission from the Engineer; except that this requirement will not be applicable to cement treatment of design soils, or bases.

The Contractor shall provide suitable means for storing and protecting the cement against dampness. Cement, which for any reason, has become partially set or which contains lumps of caked cement will be rejected. Cement salvaged from discarded or used bags shall not be used.

The temperature of bulk cement shall not be greater than 165°F at the time of incorporation in the mix.

One barrel (bbl) of cement shall be equivalent to four bags or 376 pounds.

Low-alkali cement, with maximum sodium and potassium oxides of 0.6%, will be furnished in all types.

Except when otherwise specified or prohibited, either Type I, IP or II portland cement shall be used. Type III portland cement may be used in the production of precast or prestressed concrete members.

Acceptance of hydraulic cement will be based on the certification program and job control sampling and testing as established by Department SOP.

Retests of cement may be made for soundness and expansion within 28 days of test failure and, if the cement passes, it may be accepted. Cement shall not be rejected due to failure to meet the fineness requirements if upon retests after drying at 100°C for one hour, it meets such requirements.

701.02--Portland Cement. Portland cement shall conform to Subsection 701.01 and AASHTO Designation: M 85 with the following exceptions:

The maximum values for the fineness of the grind as set out in Table 2 of AASHTO Designation: M 85 are hereby waived for Type I cement to be used in the production of prestressed concrete members.

When Portland cement concrete or cement for soil stabilization is exposed to moderate or severe soluble sulfates, or to seawater, cement types and/or replacement of cement by Class F fly ash (FA) or ground granulated blast furnace slag (GGBFS) shall be as follows:

Cementitious Materials for Soluble Sulfate Conditions

Sulfate Exposure	Water-soluble sulfate (SO ₄) in soil, % by mass	Sulfate (SO ₄) in water, ppm	Cementitious material required
Moderate and Seawater	0.10 - 0.20	150 - 1500	Type II cement or Type I cement with 25% Class F, FA or 50% GGBFS replacement
Severe	0.20 - 2.00	1500 - 10,000	Type II cement with 25% Class F, FA or 50% GGBFS replacement

701.03--Masonry Cement. Masonry cement shall conform to Subsection 701.01 and ASTM Designation: C 91.

701.04--Blended Hydraulic Cement. When permitted in the contract, blended hydraulic cement shall conform to Subsection 701.01 and AASHTO Designation: M 240.

SECTION 702 - BITUMINOUS MATERIALS

702.01--General. Bituminous materials shall include asphalt cement, cutback asphalt, or emulsified asphalt and shall meet the requirements of the applicable specifications. The material furnished for any item in any one contract shall be of one brand, type, and grade, unless special permission is obtained otherwise. Materials furnished shall exhibit uniform characteristics.

When more than one grade of material is called for under any item, the Engineer will select the grade to be used.

All sampling and reporting of bituminous materials shall be performed as set out in the Department's Standard Operating Procedures. All testing shall be performed in accordance with applicable AASHTO methods unless specifically modified by a Mississippi Test Method (MT- _____).

Bituminous material shall not be heated to a temperature which causes injury as evidenced by the formation of carbonized particles.

702.02--Measurement. Volumetric measurement of bituminous materials by the U.S. gallon will be based upon a temperature of 60°F. Corrections to this temperature for asphalt cement, cutback asphalts and emulsified asphalt will be made in accordance with the Temperature Correction Tables set out in the Department Standard Operating Procedures.

For purposes of measurement, a U.S. gallon shall be a volume of 231 cubic inches.

When bituminous material is to be paid for by the gallon, the distributor tank(s) or storage tank(s), as applicable, to be used for measurement shall be calibrated by an agency and in a manner approved by the Department. A calibration chart, showing the dimensions and volume per inch of depth, and a measuring gauge, calibrated in inches, shall be furnished to the Engineer. Each tank shall have an identifying serial number on a steel plate welded or riveted to the tank. In the event the Contractor does not have such calibration chart, previously made by an approved agency, the Department will, upon request, perform the calibration and furnish required charts; however, the Contractor will be fully responsible for any delays occasioned by such calibration by the Department.

The measurements shall be taken when the bituminous material is of a uniform temperature and free of air bubbles. In no case shall the total number of gallons of bituminous material allowed for any tank exceed the capacity of the tank as rated by either the U. S. Interstate Commerce Commission, the State Tax Commission or the Department of Transportation.

702.03--Heating Bituminous Material. Tanks for heating and storage of

bituminous materials shall be capable of heating the material to the specified temperature under effective and positive control at all times. The heating system shall provide uniform heating for the entire contents of the tank. The circulating system shall be of adequate size to insure proper and continuous circulation of the material during the entire operating period. Suitable means shall be provided, either by steamjacketing or other insulation, for maintaining the specified temperature of the bituminous material in the lines, meters, weigh buckets, spray bars, and other containers or flow lines.

Thermometers of approved type and adequate range, calibrated in five degrees F. increments, shall be located at points readily visible. These thermometers shall be kept clean and in good condition at all times.

Where storage tanks are required, the capacity shall be sufficient for at least one day's run.

The heating of bituminous materials shall be rigidly maintained at the "lowest workable temperature."

702.04--Sampling. Sampling of bituminous materials shall be as set out in AASHTO Designation: T 40.

702.05--Petroleum Asphalt Cement. Asphalt cement shall be homogeneous, free of water and shall not foam when heated to a temperature of 175°C. Except for use in hot mix asphalt, asphalt cement of the grade specified shall conform to the requirements of Subsection 702.12, Table I or II.

Bituminous material conforming to AASHTO Designation: M 320, Grade PG 58-28 may be used in lieu of petroleum asphalt cement, Grade AC-10.

The bituminous material used in all types of hot mix asphalt shall conform to AASHTO Designation: M 320, Performance Grade PG 67-22, as modified in the table below, except when otherwise specified or when polymer modified hot mix asphalt is specified.

Specifications For Performance Graded Asphalt Binders Not Addressed By AASHTO M 320		
	Grade	
Property	PG 67-22	
	Specification	Test Method, AASHTO
Original Binder		
Flash Point Temperature	minimum 230°C	T 48
Rotational Viscosity	maximum 3 Pa•s @ 135°C	T 316
Dynamic Shear, $G^*/\sin \delta$	minimum 1.00 kPa @ 67°C	T 315
Rolling Thin Film Oven Residue (AASHTO Designation: T 240)		
Mass Loss (RTFO)	maximum 1.00 %	T 240
Dynamic Shear, $G^*/\sin \delta$	minimum 2.20 kPa @ 67°C	T 315
Pressure Aging Vessel Residue (AASHTO Designation: R 28)		
Dynamic Shear, $G^*\sin \delta$	maximum 5000 kPa @ 26.5°C	T 315
Creep Stiffness, S	maximum 300 MPa @ -12°C	T 313
m-value	minimum 0.300 @ -12°C	T 313

The bituminous material used in polymer modified hot mix asphalt shall conform to AASHTO Designation: M 320, Grade PG 76-22 or PG 82-22. Unless otherwise indicated in the contract, Grade PG 76-22 will be used in polymer modified hot mix asphalt.

Asphalt cement Grade PG 76-22 & PG 82-22 shall be the product resulting from the addition of a polymer modifier to a PG 67-22 or lower grade asphalt cement and not by some other refining technique. The polymer shall meet the requirements of Subsection 702.08.3.

702.06--Cutback Asphalts. Cutback asphalt shall consist of a liquid asphalt produced by the fluxing of an asphaltic base with a suitable distillate. It shall be of uniform consistency, free of water, and shall show no separation or curdling prior to use; and shall conform to the following requirements.

702.06.1--Rapid-Curing Cutback Asphalt: AASHTO Designation: M 81.

702.06.2--Medium-Curing Cutback Asphalt: AASHTO Designation: M 82.

The standard naphtha solvent shall be used when the spot test is performed.

702.07--Emulsified Asphalt. Emulsified asphalt shall be homogeneous, showing no separation of asphalt, limits for settlement excepted, after thorough mixing, within 30 days after delivery.

Emulsified asphalts which have been subjected to freezing temperatures while in storage shall be retested and acceptance of the material shall be based on the results of such retest.

Emulsified asphalts, of the grade specified, shall conform to the following requirements:

702.07.1--Emulsified Primes. Emulsified Primes shall conform to the requirements of Subsection 702.12, Table III.

702.07.2--Anionic and Cationic. Anionic and Cationic Emulsion shall conform to the requirements of AASHTO Designation: M 140 and AASHTO Designation: M 208, respectively, with the following exceptions.

Exception: The required tests on residue may be performed on residue obtained by evaporation at 325°F., three hours, 50 grams, after filtering through a No. 50 sieve; however, in the event of the failure of any test performed on this residue, the emulsion shall be distilled and the test repeated on the residue so obtained.

702.07.3--Polymer Modified Cationic Emulsified Asphalt (CRS-2P). Polymer Modified Cationic Emulsified Asphalt shall conform to the requirements of AASHTO Designation: M 316.

702.08--Asphalt Additives.

702.08.1--Asphalt Antistrip Additives. The antistrip additive shall meet the following properties:

The bituminous mixture with antistrip additive, when tested in accordance with Mississippi Test Method MT-63, shall yield a minimum Tensile Strength Ratio (TSR) of 85 and must show an increase in indirect tensile strength for a water conditioned specimen; and by visual examination of the interior faces of the water conditioned specimen, the proportion of stripped aggregate particles shall not exceed five percent.

The rate of application shall be determined for each job-mix formula during the mix design process using Mississippi Test Method MT-63.

A stripping test, MT-63, will be performed for each job-mix formula at the beginning of plant production and thereafter, no less than one test per two week's production. A minimum of one stripping test per day of production according to Mississippi Test Method MT-59 shall also be conducted.

Should either the TSR (MT-63) or the boiling water (MT-59) stripping test fail, a new antistrip rate shall be established or other changes made immediately that will result in a mixture which conforms to the specifications; otherwise, production shall be suspended until corrections are made.

The antistrip additive shall not present any difficulties in mixing of the liquid asphalt with the particular aggregates proposed for use.

The liquid asphalt and antistrip agent mixture shall meet the viscosity requirements for the grade of liquid asphalt used in the paving mix.

702.08.2--Silicone. When specified or permitted, silicone with a viscosity of 1,000 centistokes at 77°F shall be added to the asphalt cement at the rate of one ounce per 5,000 gallons.

702.08.3--Polymers. The polymer shall be a Styrene Butadiene Styrene (SBS), a Styrene Butadiene Rubber (SBR) or an equal approved by the Engineer. The polymer shall be thoroughly blended with the asphalt cement at the refinery or terminal prior to shipment to the hot-mix plant. Producers of polymer modified asphalt cement must be listed on MDOT's Approved List of Suppliers of Polymer Modified Asphalt Cement. The producer of the polymer modified asphalt cement shall perform or have performed by an approved laboratory all tests contained in AASHTO Designation: M 320 on a lot basis. A lot shall consist of one (1) refinery or terminal storage tank not to exceed 225,000 gallons. The Producer shall furnish two copies of a certified test report (one copy for the Contractor and one copy for the Department Representative) with each shipment. A third copy of the certified test report shall be mailed to the State Materials Engineer. The certified test report shall contain the following:

- (1) Test results showing complete conformance to AASHTO Designation: M 320
- (2) Type and percentage of polymer added
- (3) A statement certifying that the transport vehicle was inspected prior to loading and was found to be empty
- (4) A statement certifying that the shipment conforms to Mississippi Department of Transportation specifications for the grade of polymer modified asphalt cement specified
- (5) A copy of the temperature-viscosity curve attached to the certified test report.

Crumb rubber used as a polymer modifier shall meet the following additional requirements:

Crumb rubber shall be produced by ambient grinding methods. The rubber shall

be sufficiently dry so as to be free flowing and to prevent foaming when mixed with asphalt cement. The rubber shall be free of contaminants including fabric, metal, minerals and other non-rubber substances. Up to four percent, by weight of rubber, of talc, such as magnesium silicate or calcium carbonate, may be added to prevent sticking and caking of the particles.

The crumb rubber shall be tested in accordance with AASHTO Designation: T 27 with the following exceptions: a 100-gram sample size and up to 25% dusting agent (talc). Rubber balls may also be used to aid in the sieving of finely ground rubber. The resulting rubber gradation shall meet the gradation limits shown herein.

<u>Gradations of Crumb Rubber</u>	
Type A	
<u>Sieve Size</u>	<u>% Passing</u>
10	--
20	--
30	--
40	100
60	98-100
80	90-100
100	70-90
200	35-60

The specific gravity of the rubber shall be 1.15 ± 0.05 when tested in accordance with ASTM Designation: D 297, pycnometer method.

The moisture content shall be determined in accordance with AASHTO Designation: T 255, with the exception that the oven temperature shall be $140 \pm 5^{\circ}\text{F}$ and the weight of the sample shall be 50 grams. The moisture content shall not exceed 0.75% by weight.

No more than 0.01% metal particles shall be detected when thoroughly passing a magnet through a 50-gram sample.

The chemical composition of the crumb rubber shall be determined in accordance with ASTM Designation: D 297 and shall meet the following requirements:

Acetone Extract	Maximum 25 percent
Rubber Hydrocarbon Content	40 to 55 percent
Ash Content	Maximum 10 percent
Carbon Black Content	20 to 40 percent
Natural Rubber	16 to 34 percent

Crumb rubber meeting these specifications shall be supplied in moisture resistant packaging such as either disposal bags or other appropriate bulk containers.

Each container or bag of crumb rubber shall be labeled with the manufacturer's designation for the rubber and the specific type, maximum nominal size, weight and manufacturer's batch or lot designation.

The producer of the polymer modified asphalt cement shall furnish the State Materials Engineer one copy of the manufacturer's certified test results covering each shipment of crumb rubber. These reports shall indicate the results of tests required by this specification. The reports shall also include a certification that the material conforms with the specifications, and shall be identified by manufacturer's batch or lot number.

702.09--Blank.

702.10--Primer For Use With Asphalt For Dampproofing and Waterproofing. Primer for use with asphalt shall meet the requirements of the Standard Specifications for Primer for Use with Asphalt in Dampproofing and Waterproofing, AASHTO Designation: M 116.

702.11--Application Temperatures. Bituminous materials for the several applications indicated in the specifications shall be applied within the temperature ranges shown in 702.12, Table IV.

702.12--Tables.

TABLE I
SPECIFICATIONS FOR ASPHALT CEMENT (PETROLEUM)

TEST	*AC-5		AC-10		**AC-13	
	Min.	Max.	Min.	Max	Min.	Max.
Viscosity @ 140°F, poises	400	600	800	1200		
Viscosity @ 275°F, C _s	175	--	240	--		
Penetration @ 32°F					25	
Penetration @ 77°F, 100g, 5 sec.	140	--	80	--	65	90
Penetration @ 115°F						325
Flash Point COC, °F	400	--	425	--	450	--
Solubility in Trichloroethylene	99.0	--	99.0	--	99.0	--
Tests on Residue from Thin-Film Oven Test:						
Viscosity, 140°F, poises	--	2250	--	4500		
Ductility, 77°F, 5 cm per min., cm.	100	--	100	--	75	--
% Loss on Heating	--	1.0	--	0.5	--	0.5
Specific Gravity @ 60°F/60°F					1.00	
Spot Test: Standard Naphtha Solvent		Negative for all Grades***				
Softening Point, °F (R & B)					110	

NOTES: * When cut-back asphalt cement is to be produced as specified in Subsection 702.06, this material shall be the base asphalt.
 ** This is an asphaltic material used primarily for sealing joints and cracks.
 *** If positive, the test must be rerun with a solution of 75% naphtha and 25% xylene.

TABLE II
SPECIFICATIONS FOR ASPHALT CEMENT (PETROLEUM)
(Continued)

TEST	AC-20		AC-30		AC-40	
	Min.	Max	Min.	Max	Min.	Max
Viscosity @ 140°F (60°C), poises	1600	2400	2400	3600	3200	--
Viscosity @ 275°F (135°C), C _s	300	--	350	--	350	
Penetration @ 32°F (0°C)						--
Penetration @ 77°F (25°C) 100g, 5 sec.	60	--	50	--	40	--
Penetration @ 115°F (46°C)						
Flash Point COC, °F	450	--	450	--	450	--
Solubility in Trichloroethylene	99.0	--	99.0	--	99.0	--
Tests on Residue from Thin-Film Oven Test:						
Viscosity, 140°F (60°C), poises	--	9000	--	13500	--	18000
Ductility, 77°F (25°C), 5 cm / min., cm.	80	--	60	--	40	--
% Loss on Heating	--	0.5	--	0.5	--	0.5
Specific Gravity @ 60°F/60°F						
Spot Test: Standard Naphtha Solvent		Negative for all Grades*				
Softening Point, °F (R & B)						

NOTES: * If positive, the test must be rerun with a solution of 75% naphtha and 25% xylene.

TABLE III
SPECIFICATION FOR EA-1 PRIME

Test Requirements	Minimum	Maximum
Furol Viscosity @ 122°F	30	100
Water Content Xylene Distillation, %	3	8
Test on Residue from Distillation		
Ductility @ 77°F, cms.	40	
Solubility in Trichloroethylene, %	97.0	
Asphalt Cement, % of Total Primer	50.0	
Penetration @ 77°F, 100 g., 5 sec.	80	300

SPECIFICATION FOR AE-P PRIME

Test Requirements	Min.	Max.	AASHTO Test Method
25°C SFS Viscosity, sec.	10	50	T-59
5-Day Settlement, %	--	5	T-59
Total Distillate, % weight	--	55	T-59
Oil Distillate, % volume	--	12	T-59
Tests on Residue from Distillation: Distillation to 500°F (AASHTO T-59)			
60°C Float Test, sec.	20	--	T-50
Solubility in TCE, %	97.5	--	T-44

TABLE IV
WORKING TEMPERATURES FOR BITUMINOUS MATERIALS

Bituminous Materials	Temperature, °F			
	Spraying		Mixing	
	Min.	Max.	Min.	Max.
Asphalt All Cements	275	350	225	350
Cutback Asphalts RC & MC				
30	80	150	60	105
70	80	150	95	140
250	100	200	135	175
800	195	270	165	205
3000	235	300	200	240

SECTION 703 - AGGREGATES

703.01--General. All aggregate sources shall be approved by the Department prior to use. All approved aggregate sources will be re-examined periodically for conformance to the quality requirements set herein.

When reference is made to the Los Angeles Test (AASHTO Designation: T 96), the percentage of wear is based on 500 revolutions, unless otherwise specified.

The term "thin or elongated piece" is intended to mean a piece whose length is more than five times its average thickness. Suspected pieces will be chosen from a representative sample, and the length and average thickness will be determined visually.

The term "fractured face" is intended to mean that the approximate area of a fractured face shall not be less than the approximate cross-sectional area at the minor axis of the particle. This area will be visually determined. A piece of aggregate with a small chipped area will not be considered as crushed.

All concrete produced for use in Department work shall be manufactured from aggregates which have been tested and accepted by Department personnel.

These general provisions shall apply, as applicable, to all the subsections of this section.

703.02--Fine Aggregate For Portland Cement Concrete.

703.02.1--General Requirements. Fine aggregate for portland cement concrete used in construction of culverts, headwalls, retaining walls, steps, or other minor structures shall consist of natural sand or manufactured limestone sand. Fine aggregate used in major construction, such as concrete pavements and bridges, shall be natural sand unless otherwise designated on the plans or in the special provisions. Natural sand, or manufactured limestone sand, shall be composed of clean, hard, durable, and uncoated particles free of deleterious substances and organic impurities. Fine aggregate from more than one source shall not be used alternately, or mixed, without the written consent of the Engineer. Approval of fine aggregate sources will be based on the following:

Soundness of aggregate shall meet the requirements set out in Subsection 703.02.2.3.

Expansion of mortar bars shall not exceed 0.5% in six months or 1.0% in one year when tested in accordance with ASTM Designation: C 227.

A source of sand may be rejected if experience proves that concrete made from the source does not have a satisfactory service record. Unless indicated

otherwise, fine aggregate shall meet the requirements hereinafter specified.

703.02.2--Detail Requirements.

703.02.2.1--Deleterious Substances. The quantity of deleterious substances shall not exceed the following limits:

<u>Deleterious Substances</u>	<u>Maximum Permissible Limits (% by Weight)</u>
Clay lumps	0.3
Coal and lignite (see Note)	0.5
Material Passing the No. 200 Sieve	2.0
Other deleterious substances such as shale, alkali, mica, coated grains, and soft and flaky particles	2.0
Total shale, coal, lignite, clay lumps, and other deleterious substances	3.0

Note: No coal or lignite will be permitted in the aggregate used for constructing superstructures of bridges.

703.02.2.2--Gradation Requirements. Fine aggregate for concrete shall be well graded from coarse to fine and shall conform to the following:

Square Mesh Sieve	Percent Passing by Weight
1/2 inch	100
3/8 inch	97 - 100
No. 4	92 - 100
No. 8	75 - 100
No. 16	45 - 90
No. 30	25 - 70
No. 50	3 - 35
No. 100	0 - 10

The gradation of material from any one source shall be reasonably uniform and not subject to the extreme gradation shown above. The degree of uniformity will be determined by fineness modulus determination from representative samples submitted from the sources the Contractor proposes to use. Fine aggregate from any one source having a variation in fineness modulus greater than 0.20 from the approved base modulus of the source may be rejected or may be accepted subject to changes in the proportions, if and as directed by the Engineer.

When the slip-form method for placement of concrete pavement is used, the fine

aggregate gradation requirements will be modified if necessary.

703.02.2.3--Soundness. When subjected to five cycles of soundness test by the use of magnesium sulfate, AASHTO Designation: T 104, the weighted percentage of loss shall not be more than 15.

703.02.2.4--Additional Requirements. Fine aggregate shall also meet the organic impurities and mortar-making properties specified in AASHTO Designation: M 6.

703.03--Coarse Aggregate For Portland Cement Concrete.

703.03.1--General Requirements. Coarse aggregate shall consist of gravel or crushed limestone unless otherwise designated or permitted on the plans or in special provisions.

The gravel or crushed limestone shall be hard, durable particles that are thoroughly clean, free from adherent coatings of injurious character, and reasonably free of soft or disintegrated pieces, frozen lumps, vegetable, or other deleterious matter. Coarse aggregate from more than one source shall not be used alternately, or mixed, without the written approval of the Engineer. Approval of coarse aggregate sources will be based on the following:

Soundness of aggregate shall meet the requirements set out in Subsection 703.03.2.3.

Resistance to abrasion shall meet the requirements set out in Subsection 703.03.2.2.

Expansion of mortar bars shall not exceed 0.5% in six months or 1.0% in one year when tested in accordance with ASTM Designation: C 227.

A source of coarse aggregate may be rejected if experience proves that concrete made from the source does not have a satisfactory service record.

703.03.2--Detail Requirements.

703.03.2.1--Deleterious Substances. The quantity of deleterious substances shall not exceed the following limits:

Deleterious Substance	For General Use	For Bridge Superstructures
	Percent by Weight	
Shale	1.00	1.00
Coal, lignite, or combination of the two	0.5	None
Clay lumps	0.3	0.3
Material passing the No. 200 sieve:		
Limestone	1.5	1.5
Other Materials	1.0	1.0
Thin or elongated pieces as referenced in Subsection 703.01	15.0	15.0
Soft fragments	3.0	3.0
Free shells	1.0	1.0
Sticks, oven-dry	None	None
Shale, coal, lignite, clay lumps, and soft fragments, total	3.0	2.5
Other deleterious substances	1.0	1.0

703.03.2.2--Percentage of Wear. When coarse aggregate is subjected to the Test for Abrasion of Coarse Aggregate, AASHTO Designation: T 96, the percentage of wear shall not be more than 40.

703.03.2.3--Soundness. When subjected to five cycles of soundness test by the use of magnesium sulfate, the weighted percentage of loss shall not be more than 15.

703.03.2.4--Gradation. Coarse aggregate for cement concrete, of the type designated, shall be well-graded from coarse to fine, and shall conform to the following:

**Table of Sizes and Gradation of Coarse Aggregate
for Portland Cement Concrete**

Square Mesh Sieves	Percent Passing by Weight			
	Size No. 467	Size No. 57	Size No. 67	Size No. 7
2 inch	100			
1 1/2 inch	95-100	100		
1 1/4 inch				
1 inch		80-100	100	
3/4 inch	35-70		80-100	100
1/2 inch		25-60		90-100
3/8 inch	10-30		20-55	40-70
No. 4	0-5	0-10	0-10	0-15
No. 8		0-5	0-5	0-5

NOTE: A maximum tolerance of three percent retained on the one-inch sieve will be allowed for aggregate Size No. 67 provided all of the material passes a one and one-fourth-inch sieve. This tolerance is not applicable for Class F and Class FX Concrete.

The gradation from any one source shall be reasonably uniform and not subject to the extreme limits of gradation shown in the table.

For the purpose of determining the degree of uniformity, a fineness modulus determination will be made upon representative samples from the sources proposed for use by the Contractor. Coarse aggregate from any one source, having a variation in fineness modulus greater than 0.20 from the approved base modulus of the source may be rejected or may be accepted subject to changes in the proportions used, as directed.

703.04--Aggregate for Crushed Stone Courses.

703.04.1--Coarse Aggregate. Coarse aggregate, defined as material retained on No. 8 sieve, shall be either crushed stone, slag, granite, shell; gravel, or combination thereof. When the required properties of the mix are not obtained with uncrushed gravel, the addition of crushed gravel or other approved material is required.

Individual sources of coarse aggregate shall conform to the following quality requirements:

Percentage of wear shall not exceed 45 when tested in accordance with AASHTO Designation: T 96.

The coarse aggregate shall have a minimum dry rodded unit weight of 70 pounds per cubic foot when tested in accordance with AASHTO Designation: T 19.

703.04.2--Fine Aggregate. Fine aggregate, defined as material passing no. 8 sieve, shall consist of hard, durable particles of naturally disintegrated rock, or material obtained by crushing stone, slag, gravel or combination thereof. Fine aggregate, when manufactured, shall be manufactured from material meeting the quality requirements for coarse aggregate, and it shall be free of lumps of clay and friable particles, loam, organic or foreign matter.

Individual sources of fine aggregate shall be non-plastic when tested in accordance with AASHTO Designation: T 90.

Natural deposits of fine aggregate shall contain no more than 10 percent by weight passing the No. 200 sieve when tested in accordance with AASHTO Designation: T 11.

Fly ash, when used as a portion of the fine aggregate to obtain desired properties of the mixture, shall be from an approved source.

When the fine aggregate is combined with other aggregate fractions in the proper proportion, the resultant mixture shall meet the requirements of Subsection 703.11 and the job-mix formula

703.04.3--Gradation. Aggregates for crushed stone shall be well-graded from coarse to fine, and shall conform to the following:

**TABLE OF SIZES AND GRADATION OF CRUSHED STONE
AGGREGATE**

Sieve Size	Percent Passing by Weight		
	Size ¾ inch and Down	Size No. 610	Size No. 825 B
2 inch			100
1 1/2 inch		100	90 - 100
1 inch	100	90 - 100	75 - 98
3/4 inch		70 - 100	
1/2 inch		62 - 90	60 - 85
3/8 inch	50 - 85	50 - 80	
No. 4	35 - 65	40 - 65	40 - 70
No. 8			28 - 54
No. 10	25 - 50		
No. 16			19 - 42
No. 40	15 - 30	12 - 26	
No. 50			9 - 32
No. 200	5 - 15	5 - 12	4 - 18

703.05--Blank.

703.06--Aggregates for Hot Mix Asphalt.

703.06.1--Coarse Aggregates. Coarse aggregate, material retained on the No. 8 sieve, shall be either crushed stone, slag, or granite; shell; expanded clay; expanded shale; crushed gravel or combination thereof. Crushed reclaimed concrete pavement shall also be allowed as a coarse aggregate provided it meets the quality requirements below and the final product produced therefrom meets all other specification requirements.

The percentage of wear shall not exceed 45 when tested in accordance with AASHTO Designation: T 96.

When tested in accordance with AASHTO Designation: T 19, the dry rodded unit weight of all aggregates except expanded clay and shale shall not be less than 70 pounds per cubic foot, and crushed slag used in the surface course shall have a dry rodded unit weight of not more than 90 pounds per cubic foot except the maximum unit weight is waived for chromium slag.

The coarse aggregate shall be free of any injurious coating which will prohibit the adherence of asphalt to the aggregate particles.

The percentage of loss shall not exceed 20 when tested for soundness using

magnesium sulfate in accordance with AASHTO T 104.

Shell shall consist of durable, washed particles of dead clam or dead reef oyster shell, or combination thereof. The shell shall be free of objectionable matter such as sticks, mud, clay lumps, cannery or live shell, or other deleterious matter. Not more than five percent by weight of the dredged material shall pass the No. 200 sieve; any such material shall be dispersed throughout the mass.

703.06.1.2--Fine Aggregates. Fine aggregate, material passing the No. 8 sieve, shall consist of hard, durable particles of naturally disintegrated rock, or material obtained by crushing stone, slag, gravel, reclaimed concrete pavement, or combinations thereof. Fine aggregate produce from crushing reclaimed concrete pavement shall be manufactured from material meeting the quality requirements for coarse aggregate.

Fine aggregate shall be free of lumps of clay and friable particles, loam, organic or foreign matter.

Fine aggregate produced by crushing stone, slag or gravel shall be manufactured from aggregate meeting the quality requirements of coarse aggregate.

Individual sources of fine aggregate shall be non-plastic when tested in accordance with AASHTO Designation: T 90.

Natural deposits of fine aggregate shall contain no more than 10 percent by weight passing the No. 200 sieve when tested in accordance with AASHTO Designation: T 11.

Individual fine aggregate components shall be of such consistency and dryness that a uniform and even flow from the cold feed will be provided.

Fly ash shall not be used in hot mix asphalt pavements.

703.07--Granular Materials.

703.07.1--General. Granular materials shall be composed of a natural or manufactured mixture of soil binder and sand; soil binder, sand and gravel; stone; slag; or combinations thereof. The mixture shall have satisfactory cementing qualities and shall be homogeneous in character and reasonably free of clay balls, vegetable matter, or other deleterious substances that cannot be classed as serviceable.

To insure adequate soil drainage through the shoulders, no material used above the design soil in the construction of shoulders shall have a minus 200 sieve fraction, liquid limit, or plasticity index appreciably exceeding like characteristics in the adjacent base courses.

703.07.1.1--Fine Aggregate (Portion Passing The No. 10 Sieve). The fine aggregate shall be composed of a natural or artificial mixture of soil binder and granular material. The soil binder shall be clay or silt or other materials, or combinations thereof having satisfactory cementing qualities, homogeneous in character, and reasonably free of vegetable matter, clay balls, or other deleterious substances that cannot be classed as serviceable. The granular portion shall be composed of sand, stone, or slag screenings and shall be hard and durable and preferably sharp.

703.07.1.2--Coarse Aggregate (Portion Retained on the No. 10 Sieve). The coarse aggregate shall be composed of gravel, stone, slag, or combinations thereof, and shall consist of hard, durable particles reasonably free of vegetable matter or other deleterious substances. Materials that break up and weather rapidly when alternately frozen and thawed or wetted and dried shall not be used.

Coarse aggregate, when tested in accordance with AASHTO Designation: T 96, shall have a percentage of wear not to exceed 50.

703.07.2--Gradation. The gradations shown in the following tables are the maxima and minima for all sources, and the gradation from any one source shall be reasonably uniform and not subject to the extreme limits in the tables. It shall be the responsibility of the Contractor to furnish a material which will have sufficient silt and clay, within the ranges permitted in the tables, to insure that the material will, when processed as specified, bind together and form a stable course and will, when properly compacted, have the required density.

The gradation of the class specified shall meet the applicable requirements of the following table:

Percentage By Weight Passing Square Mesh Sieves

Sieve Size	Class						
	1 & 2	3 & 4	5 & 6	7	8	9	10
3"	100	100	100	100	100	100	100
1 1/2"	85 - 100	85 - 100	85 - 100				
1"	65 - 100	65 - 100	65 - 100				
1/2"	35 - 90	35 - 90	35 - 100				
No. 4	30 - 70	30 - 75	30 - 85				
No. 10	30 - 50	30 - 57	30 - 65	30 - 10	30 - 100	30 - 100	30 - 100

Note: The minimum percentage passing the No. 10 sieve may be lowered to 25% by the Engineer if proper placement characteristics and stability can be obtained by the coarser gradation.

Material Passing the No. 10 Sieve

Sieve Size	Class									
	1	2	3	4	5	6	7	8	9	10
No. 10	100	100	100	100	100	100	100	100	100	100
No. 40	20 - 80	20 - 90	20 - 90	20 - 90	20 - 100	20 - 100	40 - 80	20 - 85	20 - 100	20 - 100
No. 60	15 - 70	15 - 80	15 - 80	15 - 80	15 - 80	15 - 80	30 - 70	15 - 70	15 - 85	15 - 100
No. 200	8 - 40	6 - 40	8 - 40	6 - 40	8 - 40	6 - 40	10 - 40	8 - 40	6 - 40	8 - 60

Material Passing the No. 40 Sieve shall meet the following:

Group Symbol	LL Max.	PI	
		Min.	Max.
A	25		6
B	25		8
C	30		10
**D	35		15
**E	35	6	15

General Note: Material will be designated in the contract by Class _____,
Group _____.

** In the case of Group D material, the range of PI shall be no more than nine in any half-mile section. When Group E material is specified in the contract, that portion to be treated with cement may be less plastic or non-plastic except that the range in PI shall be no more than nine in any half-mile section.

703.07.3--Sampling and Testing. The material shall be sampled and tested as outlined in Subsection 700.03.

703.08--Mechanically Stabilized Courses. Specified aggregates meeting the requirements of Subsection 703.20 when combined with soils or other aggregates as required will be tested for gradation and plasticity of the composite mixture.

In the case of gravel, stone, or slag aggregates or combinations thereof, the composite mixture will be designated in the contract as Type A, Type B, or Type C. In the case of reef shell or clam shell aggregates or combinations thereof, the composite mixture will be designated in the contract as Type D.

The composite mechanically stabilized mixture of the type and group specified in the contract shall meet the following requirements:

Percentage By Weight Passing Square Mesh Sieves

Sieve Size	Type			
	A	B	C	D
3"	100	100	100	95-100
1 1/2"	85-100	85-100	85-100	
1"	65-100	65-100	65-100	
1/2"	35-90	35-90	35-100	
No. 4	30-70	30-75	30-85	
No. 10	30-50	30-57	30-65	55(Max.)
No. 40				

Material passing the No. 40 sieve shall meet the following:

Group Symbol	LL Max.	PI	
		Min.	Max.
A	25		6
B	25		8
C	30		10
**D	35		15
**E	35	6	15

Note: Desired product will be designated in the contract as Type _____,
Group _____.

703.09--Blank.

703.10--Blank.

703.11--Blank.

703.12--Blank.

703.13--Aggregate for Cold Bituminous Pavement. The fine and coarse aggregate fractions for the mixture shall be so sized and graded that when combined the resultant mixture will be uniformly graded from coarse to fine and meet the applicable requirements of the gradation table.

703.13.1--Coarse Aggregate. The coarse aggregate shall be crushed slag, crushed limestone, crushed gravel, expanded clay, granite, crushed reef shell or a combination thereof and shall meet the quality requirements of Subsection 703.09.

Crushed processed reef shell shall consist of dead oyster shell, dead clam shell, or combinations thereof. It shall not contain cannery or live shell. The uncrushed shell shall be produced or processed by washing over a screen washer. The mesh of the screen washer shall not be smaller than 1/4 inch. Before crushing, material passing the No. 200 sieve shall not exceed four percent.

703.13.2--Fine Aggregate. Fine aggregate shall meet the quality requirements of Subsection 703.09. When crushed limestone or crushed reef shell is used as the coarse aggregate, at least 60% of the fine aggregate portion of the mixture shall consist of naturally disintegrated rock.

703.13.3--Aggregate for Top Dressing. Material for top dressing shall consist of dry sand, gravel screenings, stone screenings or slag screenings and conform to the following gradation requirements:

<u>Square Mesh</u> <u>Sieve</u>	<u>Percent Passing</u> <u>By Dry Weight)</u>
3/8 inch	100
No. 4	95 (min.)
No. 50	30 (max.)
No. 100	5 (max.)

**GRADATION REQUIREMENTS
COLD BITUMINOUS PAVEMENTS**

Type:	Binder	Binder	Binder	Surface	Surface	Surface	Surface
Designation:	A	B	C	D	E	F	G
Sieve:	(Percent Passing by Weight, Aggregate Only)						
1 1/2 inch	100						
1 1/4 inch	90-100						
1 inch		100					
3/4 inch		90-100	100		100		
5/8 inch	30-60				90-100		
1/2 inch		40-85	80-100	100		100	100
3/8 inch			60-90	90-100		95-100	90-100
No. 4	5-25	10-35	45-75	60-98	10-40	40-70	
No. 10	0-15	5-20	35-60	35-70	5-30	15-50	50-90
No. 40	0-5	0-12	12-30	14-35	1-20	5-30	20-55
No. 80			4-20	3-15	0-15	1-20	7-30
No. 200	0-2	0-6	1-10	0-5	0-5	0-10	2-12
% A.C. by Weight of							
Total Mix	3.5-5.5	4.0-7.0	5.0-8.0	5.0-8.0	4.5-6.5	4.5-8.5	5.8-8.5*
Liquefier**	Max.2.0	Max.2.0	Max.2.0	Max.2.0	Max.2.0	Max.2.0	Max.2.0
Hydrated Lime***	0.5-1.5	0.5-1.5	0.5-1.5	0.5-1.5	0.5-1.5	0.5-1.5	0.5-1.5

* These limits include the natural asphalt recoverable by extraction in natural asphaltic limestone, and aggregate gradation limits include sand added in accordance with Subsection 703.13.2.

** Liquefier shall be commercial grade Naptha or Kerosene.

*** Hydrated lime, for facilitator, shall meet Subsection 714.03.

RANGE OF TOLERANCES

Passing No. 10 and larger sieves-----	± 10%
Passing Nos. 40 and 80 sieves-----	± 7%
Passing No. 200 sieve -----	± 3%
Percent Asphalt Cement-----	± 0.5%
Percent Liquefier-----	± 0.5%

703.14--Aggregate for Bituminous Surface Treatments.

703.14.1--General Requirements. Aggregate for bituminous surface treatments and liquid seals shall consist of crushed stone, crushed slag, gravel, or expanded clay as specified in the contract.

Only one kind and type of aggregate shall be used on a single course unless otherwise authorized by the Engineer in writing.

703.14.2--Detail Requirements.

703.14.2.1--Gradation. Aggregates shall conform to the gradation requirements contained in the following table:

GRADATION REQUIREMENTS FOR COVER AGGREGATE

Square Mesh Sieve	Coarse Aggregate Cover Material			Seal Aggregate Cover Material			
	Slag, Stone, Granite or Gravel (Crushed or Uncrushed)			Slag, Stone, Granite or Crushed Gravel		Slag or Expanded Clay	
	Size No. 5	Size No. 56	Size No. 6	Size No. 7	Size No. 89	Size No. 7	Size No. 8
Percent Passing Square Opening Sieves							
1 1/2 inch	100	100					
1 inch	90-100	90-100	100				
3/4 inch	20-55	40-85	90-100	100		100	
1/2 inch	0-10	10-40	20-55	90-100	100	90-100	100
3/8 inch	0-5	0-15	0-15	40-85	90-100	40-85	85-100
No. 4		0-5	0-5	0-15	20-55	0-15	10-30
No. 8				0-5	5-30	0-5	0-10
No.16					0-10	0-5	0-5

The size coarse aggregate cover material and the size seal aggregate cover material shall be as specified in the bid schedule of the contract; however, only one kind of aggregate shall be used unless otherwise authorized by the Engineer in writing.

703.14.2.2--All Materials. The quantity of deleterious substances shall not exceed the limits set out in Subsection 703.03.2.1 for general use.

When subjected to five cycles of Soundness Test for Coarse Aggregate by use of magnesium sulfate, the weighted percentage of loss shall not be more than 15.

The percentage of wear, when tested for abrasion in accordance with AASHTO Designation: T 96, shall not be more than 40%.

703.14.2.3--Crushed Stone. Crushed stone shall consist of clean, tough, durable, uncoated fragments free from an excess of soft or disintegrated pieces.

703.14.2.4--Crushed Slag. Crushed slag shall be air-cooled slag consisting of angular fragments, reasonably uniform in density and quality, and reasonably free of dirt or other objectionable matter. Crushed slag shall have a dry-rodded weight of 70 to 90 pounds per cubic foot when tested in accordance with AASHTO Designation: T 19 and shall not contain more than 10 percent by weight of glassy particles. The maximum unit weight is waived for chromium slag.

703.14.2.5--Crushed Gravel. Crushed gravel shall be composed of clean, tough, durable particles of gravel, free from excess dirt or other objectionable matter. At least 85% by weight of the particles retained on the No. 10 sieve shall have one or more fractured faces.

703.14.2.6--Uncrushed Gravel. Uncrushed gravel shall be composed of clean, tough, durable particles free from excess vegetable or other objectionable matter. It shall meet the requirements specified above for all materials as to deleterious substances.

703.14.2.7--Expanded Clay. Expanded clay aggregate shall be the product of a plant approved by the Engineer. It shall conform to the gradation requirements in the preceding table and to requirements of ASTM Designation: C 330, with the following exception: The loss by abrasion shall not be more than 40% when subjected to the Los Angeles Abrasion Test, AASHTO Designation: T 96.

When used for sealing joints as specified in Section 413, the soundness and abrasion requirements will be waived.

703.15--Blank.

703.16--Mineral Filler. Mineral filler shall consist of shell dust, limestone dust, portland cement, or other calcareous type materials having a high affinity for asphalt. The source of the material shall be approved by the Engineer.

Mineral filler shall meet the following gradation requirements:

Passing the No. 30 sieve, %-----	100
Passing the No. 50 sieve, not less than, % -----	95
Passing the No. 200 sieve, not less than, %-----	65

703.17--Blank.

703.18--Mortar Sand. Sand for mortar shall consist of hard, strong, durable, uncoated mineral or rock particles, free of injurious amounts of organic or other deleterious substances. It shall not contain, by weight, more than three percent clay or inorganic silt or combination thereof.

Mortar sand shall be uniformly graded from coarse to fine within the following limits:

<u>Sieve Size</u>	<u>% Passing</u>
No. 4	100
No. 8	97-100
No. 50	8-40
No. 100	0-10
No. 200	0-5

Mortar sand shall meet other requirements of AASHTO Designation: M 45.

703.19--Lightweight Aggregate for Structural Concrete. Lightweight aggregates for structural concrete shall meet the requirements of AASHTO Designation: M 195.

703.20--Aggregate for Stabilizer.

703.20.1--General Requirements. The material for stabilizer aggregate shall meet the requirements hereinafter specified for each type.

The gradation limits shown below are the maxima and minima for all cases, and a closer control appropriate to the job materials will be required for the specific project. Each type of aggregate shall be uniformly graded from coarse to fine. Skip-graded material will not be acceptable.

703.20.2--Detail Requirements.

703.20.2.1--Gravel, Stone, or Slag Coarse Stabilizer. Gravel or stone shall be composed of hard, tough, durable particles reasonably free of injurious or deleterious substances. The percentage of wear, when tested in accordance with AASHTO Designation: T 96, shall not exceed 50%.

Slag shall be air-cooled slag, consisting of angular fragments, reasonably uniform

in density and quality, and reasonably free of dirt or other objectionable matter. The weight per cubic foot shall be not less than 70 pounds. The percentage of wear, when tested in accordance with AASHTO Designation: T 96, shall not exceed 50%.

703.20.2.2--Shell. Shell shall consist of durable, washed particles of slaked clam or reef shell or combination thereof. The shell shall be free of objectionable matter such as sticks, mud, clay lumps, or other deleterious matter. Not more than four percent by weight of clay and sand will be permitted and such material shall be dispersed throughout the mass.

Clam shell shall consist of washed dead clam shell. Reef shell shall consist of washed dead oyster shell and shall not contain cannery or live shell.

703.20.2.3--Medium and Fine Stabilizer. Medium aggregate stabilizer and fine aggregate stabilizer shall consist of sand, stone, shell, and/or slag screenings.

Slag screenings, sand, or stone shall be composed of hard, durable particles reasonably free of injurious amounts of soft or flaky particles, dust lumps, organic, or other deleterious substances. Shell shall comply with the requirements set out in Subsection 703.20.2.2.

703.20.3--Gradation. The gradation of the various types of stabilizer shall be as follows:

PERCENT PASSING BY WEIGHT

Square Mesh Sieves	Shell	Coarse		Medium Fine	
		Gravel, Stone, or Slag		Gravel, Stone, Slag or Shell	
		Size I	Size II Note (1)		
2 1/2 inch	90-100				
2 inch		100			
1 1/2 inch		90-100	100		
1 inch		80-100	97-100		
3/4 inch		55-100	55-100		
1/2 inch		35-85	35-85	100	
3/8 inch		12-65	12-65	97-100	
No. 4, Note (2)		0-30	0-30	92-100	
No. 10		0-8	0-8	80-100	100
No. 40				10-40	80-100
No. 60	0-5			0-20	30-100
No. 100					15-80
No. 200		0-4	0-4	0-5	0-30
PI Material					
Passing No.40				6 or less	0

Note (1): Size II is intended for use in bases in which portland cement is used.

Note (2): Ground shell shall contain at least 97% passing the No. 4 sieve.

703.20.4--Stabilizer Aggregate, Local Materials. When local materials are designated for use as stabilizer aggregate, their requirements will be shown on the plans or in the special provisions.

703.21--Borrow Excavation. Borrow excavation shall be composed of a natural or manufactured mixture of sand, silt, and clay or combinations of sand, silt, clay, gravel or stone. The material shall have satisfactory cementing qualities, shall be reasonably free of vegetable matter or other deleterious substances that cannot be classed as serviceable, and shall be such that when properly compacted will form a dense mass. When rock or stone is used in the embankment, it shall be so graded and manipulated that the embankment will contain no appreciable interstices.

Borrow excavation from outside the right-of-way is divided into classes, each class conforming to the requirements set out in the following table:

BORROW EXCAVATION

		CLASS																
		B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17
Percent Passing	(Min.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36	8
No. 200 Sieve	(Max.)	25	35	10	35	35	35	100	100	100	100	-	-	-	-	-	-	50
Percent Passing	(Min.)	-	-	-	-	-	-	-	-	-	-	8	8	8	8	-	-	-
No. 270 Sieve	(Max.)	-	-	-	-	-	-	-	-	-	-	100	70	100	100	-	-	-
Percent Silt	(Max.)	-	-	-	-	-	-	-	-	-	-	90	50	90	75	-	-	-
Fraction Passing																		
No. 40 Sieve -																		
Liquid Limit	(Max.)	-	40	-	45	40	45	40	55	40	55	45	40	55	45	-	40	40
Plasticity Index	(Max.)	6	10	np	10	20	25	10	10	20	-	25	20	35	25	35	-	12
	(Min.)	-	-	-	-	-	-	-	-	-	-	-	-	10	-	10	11	-
% Volume Change	(Max.)	-	-	-	-	-	-	-	-	-	-	-	-	60	-	50	50	-
Group Index	(Max.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-

The Class of material will be specified in the contract.

When the contract contains a numerical designation after the class number, it shall be understood to indicate the requirement that the material shall have a minimum PI of not less than that indicated by the numerical designation. For example, Class B9-6 requires Class B9 material having a minimum PI of 6; or a Class B9-10 requires Class B9 material having a minimum PI of 10, etc.

When a minimum PI is specified, the maximum plasticity index and the maximum liquid limit, as indicated in the table, will be raised the numerical designation for minimum PI, except that in the case of Class B8, Class B10 and Class B13 the maximum liquid limit shall remain as indicated in the table above.

For the design soil portion of the embankment all of the material shall pass a three-inch sieve. Individual contracts may further restrict the maximum size of material in the top portion of the design soil.

SECTION 704 - AGGREGATE FOR DRAINAGE

704.01--Permeable Material. Permeable material for use in backfilling trenches, under, around, and over underdrains and permeable material for blankets or other subdrainage purposes shall consist of hard, durable, clean sand, gravel, crushed stone, or crushed slag, and shall be free from organic material, clay balls, or other deleterious substances. These materials shall be as designated by Type as set out below.

704.02--Type A Filter Material. Type A filter material shall meet the requirements for Size 7 seal cover aggregate, or Size 7, 57, or 67 coarse aggregate for portland cement concrete, or Size II gravel coarse stabilizer as set out in Section 703. The crushing requirement for gravel seal cover aggregate is not applicable.

704.03--Type B Filter Material. Type B filter material shall be concrete sand conforming to the requirements of Subsection 703.02, except that the requirements for fineness modulus (FM) will not apply.

704.04--Type C Filter Material. Type C filter material shall consist of sand, stone, and/or slag screenings composed of hard, durable particles reasonably free of injurious amounts of soft or flaky particles, dust, lumps, organic, or other deleterious substances.

The gradation of the material shall be as follows:

<u>Sieve Size</u>	<u>Percent Passing</u>
1/2 inch	100
No. 4	80-100
No. 16	37-80
No. 50	5-30
No. 100	0-10

704.05--Type D Impervious Material. Type D impervious material shall consist of natural soil, soil aggregates, or a blend of natural soil and aggregates. The material shall be reasonably free of sticks, roots and other objectionable matter, shall be classified as Group A-6 or A-7, and shall conform with the following:

Percent passing No. 10 Sieve -----	80-100
Percent passing the No. 200 Sieve, minimum -----	36
Liquid Limit, maximum -----	50
Plasticity Index -----	12 to 25
pH-----	4.5 to 8.0

704.06--Crushed Stone Drainage Layers. The aggregate shall be crushed limestone, sandstone or granite conforming to the quality requirements of Subsections 703.01 and 703.03. The aggregate shall conform to the gradation set out below.

<u>Sieve Size</u>	<u>% Passing by Weight</u>
1 1/2"	100
1"	95 - 100
1/2"	60 - 82
No. 4	35 - 55
No. 8	5 - 25
No. 16	3 - 11
No. 50	2 - 7

**SECTION 705 - STONE BLANKET PROTECTION
AND FILTER BLANKET MATERIALS**

705.01--Stone Blanket Protection. In addition to meeting the quality requirements of AASHTO Designation: M 80, Class E, stone blanket protection shall be in accordance with AASHTO Designation: M 43, Size No. 357.

705.02--Stone Filter Blanket. In addition to meeting the quality requirements of AASHTO Designation: M 80, Class E, filter blanket material shall conform to

the gradation requirements of AASHTO Designation: M 43, Size No. 467.

705.03--Sand Filter Blanket. The sand filter blanket shall conform to the gradation requirements of Subsection 703.02 for concrete sand.

705.04--Stone Riprap. Aggregate for loose riprap, stone riprap for foundation protection, or that to be grouted shall consist of field stone, broken concrete, or rough, unhewn quarry stone as nearly rectangular in section as is practicable. The stone shall be dense, free of clay or shale seams, resistant to the action of air and water, and suitable in all other respects for the purpose intended. Quality requirements for rock to be furnished under these specifications will be checked or tested as determined by the State Materials Engineer prior to use and subsequently if deemed appropriate.

Stones for riprap, of the size specified, shall meet the requirements for size by weight of the mass as specified in the following table:

PERCENTAGE LARGER THAN
By Weight of the Mass

Rock Size	Size								
	8 Ton	4 Ton	2 Ton	1 Ton	1/2 Ton	1/4 Ton	300 Pound	200 Pound	100 Pound
8 Ton	50	0							
4 Ton	85	50	0						
2 Ton	--	95	50	0					
1 Ton	--	--	95	50	0				
1/2 Ton	--	--	--	95	50	0			
1/4 Ton	--	--	--	--	95	50			
300 Pound	--	--	--	--	--	--	0		
200 Pound	--	--	--	--	--	--	--	0	
100 Pound	--	--	--	--	--	--	--	--	0
75 Pound	--	--	--	--	--	90	--	--	--
60 Pound	--	--	--	--	--	--	80	--	--
40 Pound	--	--	--	--	--	--	--	80	--
20 Pound	--	--	--	--	--	--	90	--	80
10 Pound	--	--	--	--	--	--	--	90	--
5 Pound	--	--	--	--	--	--	--	--	90

This table sets out minimum requirements for the large stone per size designation. The Contractor shall furnish material well graded with the smaller stones such that a homogeneous blanket of riprap will result with all interstices reasonably well filled with rock.

SECTION 706 - MASONRY UNITS**706.01--Brick.**

706.01.1--General. Brick shall have a fine-grained, uniform, and dense structure, and be free of lumps of lime, laminations, cracks, checks, soluble salts, or other defects which may in any way impair the strength, durability, appearance or usefulness of the brick for the purpose intended. Bricks shall emit a clear, metallic ring when struck with a hammer.

706.01.2--Building Brick. Unless otherwise stipulated, building brick shall conform to AASHTO Designation: M 114, Grade SW.

706.01.3--Sewer and Manhole Brick. Unless otherwise stipulated, brick for sewer and manholes shall conform to AASHTO Designation: M 91, Grade SM.

706.02--Concrete Brick. Concrete brick shall conform to ASTM Designation: C 55, Grade N, Type I.

706.03--Concrete Masonry Blocks. Concrete masonry blocks may be rectangular or segmented and, when specified, shall have ends shaped to provide interlock at vertical joints. The blocks shall conform to the requirements of ASTM Designation: C 139; or, for hollow blocks, to ASTM Designation: C 90, Grade N, Type I. Dimensions and tolerances shall be as specified.

706.04--Right-of-Way Markers.

706.04.1--General. Concrete right-of-way markers shall be constructed in conformity with the details shown on the plans and shall meet the requirements hereinafter set forth. When more than 20% of the units in a lot is rejected, the entire lot will be rejected.

706.04.2--Manufacture.

706.04.2.1--Description. The exposed portion of the marker shall present a smooth, uniform surface, free of honeycomb, chips, or other defects. The shape, dimensions, and placement of steel shall be in accordance with details shown on the plans. All letters, figures, or other markings shall be true to type and size shown on the plans, and shall be legible.

706.04.2.2--Materials. The materials used in the manufacture shall conform to the following:

706.04.2.2.1--Cement. The cement used shall meet the requirements of Section 701.

706.04.2.2.2--Aggregates. The aggregates used shall conform to the requirements of Subsections 703.02 and 703.03, except that the requirements for gradation will not apply.

706.04.2.2.3--Reinforcing Steel. Reinforcing steel shall conform to the requirements of Subsection 711.01.

706.04.2.2.4--Proportions. The concrete shall have a minimum cement factor of 1.25.

706.04.2.2.5--Strength Requirements. The strength of the right-of-way markers shall be determined by the beam method. Under the beam method, a completed unit is loaded at the midpoint of an 18-inch span with three-edge bearing; the unit shall develop a strength of not less than 12,000 pounds, total load. Two specimens will be tested for each 200 units, or increment thereof; one to destruction and one to the ultimate load of 12,000 pounds.

SECTION 707 - JOINT MATERIALS

707.01--General. Joint fillers and seals for concrete bridges, concrete pavements or base course, and culvert pipe shall conform to the following applicable subsections.

707.02--Joint Fillers.

707.02.1--Poured Joint Filler.

707.02.1.1 Asphalt Joint Material. Poured asphalt filler shall be blown asphalt, Grade AC-13, conforming to the requirements of Subsection 702.05.

707.02.1.2--Polymerized Emulsified Asphalt Joint Material. Cold applied polymerized-emulsified asphalt joint material shall meet the following requirements when tested in accordance with AASHTO Designation: T 59 and as specified below:

	Minimum	Maximum
Tests on Emulsion		
Viscosity, Saybolt FuroI @ 122°F, seconds	50	450
Storage Stability, 24 hr., % *	-	1
Classification Test	Pass	
Particle Charge Test	Positive	
Cure Test **	Pass	
Stretch Test ***	Pass	
Distillation:		
Oil distillate by volume of emulsion %	-	2
Residue from distillation, %	65	-

Tests on Residue from Distillation

Penetration, 77°F, 100 g., 5 seconds	80	150
Ductility, 77°F, cm	40	-
Solubility in Trichloroethylene, %	97.5	-

- * Note 1: Upon examination of the test cylinder after standing undisturbed for 24 hours, the surface shall show no white, milky colored substance but shall be a homogeneous brown color throughout.
- ** Note 2: Cure Test - Pour approximately one milliliter of the emulsion onto a metal surface. Allow to cure at a minimum temperature of 80°F under a bright light for four hours. Outside in the sun may be used as the test site. After the four-hour curing period, the material shall show no tackiness or tendency to stick to the finger when pressed.
- *** Note 3: Stretch Test - Pour onto a one-quart friction lid, or similar flat container, enough emulsion to cover the surface. While the emulsion is still brown, embed with thumb pressure several clean, sharp edged rocks of 3/8 to 1/2 inch size. Cure in oven at 100°F for a minimum of eight hours. Remove from oven and allow to cool at room temperature for one hour. Upon lifting a rock from the surface, the asphaltic material must stretch for a distance of three inches before breaking.

707.02.1.3--Concrete Joint Sealer Compound - Hot-Poured Elastic Type. Concrete joint sealer compound, hot-poured elastic type, shall conform to the requirements of AASHTO Designation: M 173.

707.02.1.4--Silicone Sealant. The silicone sealant must have been approved for listing in the Department's "Approved Sources of Materials" prior to its use. The silicone sealant shall be a single-component low modulus non-acetic acid cure sealant which does not require a primer for bond to concrete. Unless specifically designated otherwise, silicone sealant shall be either the standard non-sag type or the self-leveling type meeting the following requirements:

PHYSICAL REQUIREMENTS

Property	Standard Non-Sag Type	Self- Leveling Type
Shore A Durometer Hardness, 7-day cure @ 73.4 ±3.6°F & 45% to 55% R.H., ASTM Designation: D 2240	10 - 25	15 maximum
Elongation, 7-day cure @ 73.4 ±3.6°F & 45% to 55% R.H., ASTM Designation: D 412, Method A, Die C, minimum	500%	500%
Tensile Stress @ 150% Elongation, 7-day cure @ 73.4 ±3.6°F & 45% to 55% R.H., ASTM Designation: D 412, Method A, Die C	20 - 45 psi	10 - 30 psi
Flow/Sag, ASTM Designation: C 639, maximum	0.3 inch	Self-Leveling
Tack-Free Time, 73.4 ±3.6°F & 45% to 55% R.H., ASTM Designation: C 679, maximum	90 minutes	180 minutes
Shelf Life from Date of Manufacture, minimum	6 months	6 months

The manufacturer of the joint material shall furnish certified test results of each lot of material furnished to each project. Each lot of the sealant shall be delivered in containers plainly marked with manufacturer's name or trade mark, lot number and date of manufacture.

707.02.1.5--Backer Rod for Use with Hot and Cold Poured Joint Sealer. The backer rod shall be a closed-cell foam rod made from polyethylene, polyolefin or similar type material and must have been approved for listing in the Department's "Approved Sources of Materials" prior to its use. The backer rod shall not wick water or retain moisture. The backer rod shall meet the following requirements:

Property	Value	Test Method
Density, maximum	2.5 lbs/ft ³	ASTM D 1622
Tensile Strength, minimum	15 psi	ASTM D 1623
Water Absorption, maximum	0.02 g/cm ³	ASTM C 1016, Procedure A
Compression Deflection, maximum	25% at 10 psi	ASTM D 1621

Temperature Requirements, minimum	450°F	No visible damage, when in contact with hot sealant
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NOTE: The temperature requirement shall not apply for use with cold-poured joint sealer.

707.02.1.6--Tar. Tar filler shall be produced from suitable gas-house, coke-oven, and/or water-gas tars and shall conform to the following requirements:

	Minimum	Maximum
Float Test at 122°F	75	100
Total Distillate, percent by weight to 572°F	-	25
Water, percent by volume		1
Bitumen soluble in CS ₂ , percent	80	-
Softening Point of Residue (R & B), °F		162
Specific Gravity, 60°F/60°F	1.20	1.28

707.02.2--Preformed Joint Filler. Preformed joint filler shall conform to AASHTO Designation: M 153 for cork or sponge rubber types or AASHTO Designation: M 213 for bituminous types. The type required will be indicated on the plans.

707.02.3--Wood. Wood board joint filler shall be redwood, cypress, yellow pine, white pine, fir, longleaf pine, Tupelo gum, or other lumber classed as softwood, and shall conform to the following requirements:

Boards shall be free of knots, except that small pin knots 1/4 inch maximum diameter will be permitted. Boards containing occasional knots of larger size may be used, provided the knots are removed and the holes either filled with properly sized plugs of the same type wood or covered with approved thin metal attached to the board. Occasional medium surface checks not to exceed 1/32 inch width and 10 inch length will be permitted, provided the board is free of defects that will impair its usefulness for the purpose intended.

Dimensions shall be as shown on the plans, and tolerances of plus or minus 1/16 inch thickness and plus or minus 1/8 inch width will be permitted. For slip-form paving a tolerance of minus 1/4 inch on each end in length will be permitted.

The oven-dry weight shall not exceed 38 pounds per cubic foot, and the load required to compress the material in an oven-dry condition to 50% of its thickness before test shall not be more than 2500 psi.

A sample shall be submitted for each shipment of 1000 linear feet or less. Each sample shall consist of a representative section at least 36 inches long and the full depth of the joint. Testing shall be in accordance with AASHTO Designation: T 42, as applicable.

The joint filler shall be a one-piece board or a lamination of like species of the required thickness, depth and lane width length without joints or splicing except that milled shop finger end joints are permissible.

707.02.4--Preformed Joint Insert Material for Concrete Paving. Preformed joint insert material shall be composed of 1/4 x 2-inch preformed, non-extruding fiber board. The fiber shall be impregnated with asphalt or other approved binding material. The fiber board shall be of such character as not to be deformed or broken by twisting, bending, or other ordinary handling when exposed to atmospheric conditions. Pieces of the joint filler that have been damaged shall be rejected. This material is for use in longitudinal joints.

707.02.5--Preformed Elastomeric Compressive Joint Seals for Concrete. The preformed elastic joint shall be a polychloroprene joint sealer of the size and shape shown on the plans, bonded to the concrete with a lubricant adhesive and shall conform to AASHTO Designation: M 220.

The lubricant adhesive shall be in accordance with the recommendation of the manufacturer of the joint seals.

The Contractor shall submit the manufacturer's certified test results for each lot of joint seals.

707.03--Blank.

707.04--Rubber Type Gaskets for Joining Conduit. Rubber gaskets for pipe joints and revisions in design of pipe for installation of the gaskets shall conform to the requirements of AASHTO Designation: M 315. The Contractor shall submit the manufacturer's certified test results for each consignment of material.

707.05--Bituminous Plastic Sealer for Joining Conduit. Bituminous plastic sealer shall be composed of steam-refined petroleum asphalt or refined coal tar which has been dissolved in a suitable solvent and stiffened with an inert mineral filler.

The sealer shall be a smooth uniform mixture, not thickened or livered; it shall show no separation which cannot be easily overcome by stirring. The material shall be of such consistency and properties that it can be readily applied with a trowel, a putty knife, or a caulking gun without pulling or drawing. The material, when applied to pipe surfaces, shall exhibit good adhesive and cohesive properties and shall have only slight shrinkage after curing. The material shall be

capable of being exposed to below freezing temperatures without incurring damage. When applied in a layer of 1/16 inch to 1/8 inch thick on a tinned metal panel and cured at room temperature for 24 hours, the bituminous plastic sealer shall set to a tough plastic coating, free of blisters. Additional requirements are:

	Minimum	Maximum
Grease cone penetration, unworked, 150 grams, 25°C, 5 sec., ASTM Designation: D 217, mm/10	175	250
Weight, pounds per gallon	9.75	-
Non-volatile, 19 grams, 105°C - 110°C, 24 hrs., %	75	-
Ash, by ignition, %	25	55

707.06--Flexible Plastic Gasket for Joining Conduit. Gasket joint seals shall be produced from blends of refined hydrocarbon resins and plasticizing compounds reinforced with inert mineral filler and shall contain no solvents. The gasket joint sealer shall not depend on oxidizing, evaporating, or chemical action for its adhesive or cohesive strength and shall be supplied in extruded rope form of suitable cross-section and of such size as to fill the joint space when the pipes are laid. The gasket joint sealer shall be protected by a suitable removable two-piece wrapper. The two-piece wrapper shall be so designed that one-half may be removed longitudinally without disturbing the other half.

The material shall be obtained from sources approved by the laboratory, and the approval will be based on results of testing as required herein.

The Department may require the performance test described in AASHTO Designation: M 198.

Flexible plastic gasket shall also meet the following requirements:

	Minimum	Maximum	Test Method
Composition			
Bitumen / Petroleum Plastic Content	50	70	ASTM D 4
Ash-Inert Mineral Matter	30	50	AASHTO T 111
Volatile Matter	--	2.0	ASTM D 6
Property			
Specific Gravity at 77°F	1.20	1.35	ASTM D 71
*Ductility at 77°F (cm)	5.0	--	ASTM D 113
*Softening Point	320°F	--	ASTM D 36
*Penetration 77°F, 150 g, 5 sec.	50	120	ASTM D 217

* Due to the nature of the material, each sample to be tested must be manually kneaded, in lieu of heating and pouring, into the testing containers.

The Contractor shall furnish the Engineer three copies of the manufacturer's certificate, stating that the flexible plastic gasket meets all the requirements of these specifications and has the properties and characteristics herein specified.

707.07--Neoprene Expansion Joints.

707.07.1--General. Neoprene expansion joints shall consist of an integrally molded unit of neoprene and bonded metal components or neoprene extrusions bonded to steel extrusions so arranged as to provide for the expansion and contraction movements of the bridge deck.

707.07.2--Material Requirements. Materials used in the manufacture of the expansion joints shall meet the following requirements:

Neoprene shall meet the requirements of AASHTO Designation: M 220.

Steel plates bonded in the joints and steel extrusions shall conform to the requirements of ASTM Designation: A 36.

Aluminum plates used in the manufacture of the expansion joints shall conform to the requirements of ASTM Designation: B 209, Alloy 6061-T6.

Anchor bolts or studs shall be of a weldable alloy if arc welding is used, and shall conform to the strength requirements of ASTM Designation: A 307, Grade A Low Carbon Steel Fasteners.

707.07.3--Certification of Materials. The Contractor shall furnish the Engineer three copies of the manufacturer's certificate, stating that the expansion joint and each component material meets all the requirements of these specifications and have the properties and characteristics herein specified.

SECTION 708 - NON-METAL STRUCTURES AND CATTLEPASSES

708.01--General. The structures covered in these specifications are for use as pipe culverts, precast box culverts, cattlepasses, sidedrains, sewers, underdrains, and downspouts.

708.02--Concrete Pipe. Unless otherwise specified, pipe and tile shall conform to the requirements hereinafter set forth. When more than 20% of the pipe in a lot is rejected, the entire lot of pipe will be rejected.

When elliptical reinforcing is used, lift holes shall be cast in the top and "Top" or "Bottom" shall be clearly inscribed or stenciled on the inside of the pipe to indicate the proper position when laid. When it is found that the position for laying is not marked, or is marked improperly, the entire lot of such pipe will be

rejected.

When rubber gasket joints are permitted or specified, the pipe joints shall be so constructed as to accommodate this type of jointing.

708.02.1--Materials for Use in Concrete Pipe.

708.02.1.1--Cement. Portland Cement Types I, II or III, or blended hydraulic cement, shall conform to the requirements set out in Section 701.

708.02.1.2--Fly Ash. Fly ash conforming to the requirements of Subsection 714.05 may be used to replace portland cement on a one to one replacement rate but not to exceed 20 percent by weight of the portland cement.

708.02.1.3--Fine Aggregate. Fine aggregate shall consist of natural sand and shall conform to the requirements set out in Subsection 703.02, except that the requirements for gradation are not applicable.

708.02.1.4--Coarse Aggregate. Coarse aggregate shall consist of gravel or crushed limestone conforming to the requirements of Subsection 703.03, except that the requirements for gradation are not applicable. Concrete pipe made with crushed limestone coarse aggregate will not be permitted for use on a project with a soil pH lower than 4.5.

708.02.1.5--Water. The water shall conform to the requirements set out in Subsection 714.01.2.

708.02.1.6--Reinforcement. Reinforcement shall consist of wire conforming to the applicable requirements of Subsection 711.02.

708.02.2--Manufacture. General. Circular pipe of 54-inch diameter and smaller shall be machine made. Other pipe may be either machine made or wet cast.

All sizes of concrete pipe may be furnished with either bell and spigot or tongue and groove, provided that the minimum thickness of concrete on the groove end is at least 1¼ inches. This measurement for thickness will be made at a point 3/8 inch from the outer end of the groove.

When no particular length is specified, the pipe shall be manufactured in standard lengths of at least 2½ feet and not more than eight feet.

The pipe shall be constructed in such a manner and of such design that the joint will meet the same requirements for strength stipulated for the pipe.

708.02.3--Exceptions to AASHTO Standard Specifications.

708.02.3.1--Liquid Membrane Curing Compound. Liquid membrane curing compound will not be permitted.

708.02.3.2--Marking. Required markings shall be placed on the inside wall of the pipe. Machine made pipe shall be inscribed on the outside of the pipe and stenciled on the inside, other pipe may be stenciled. The specification designation for reinforced pipe may be excluded from the required markings.

708.02.3.3--Basis of Acceptance. All pipe will be tested under Option I, three-edge bearing test, or Option II, cylinder test, as set forth in Department SOP.

Pipe having a diameter of 30 inches or less will be tested under Option I.

Pipe larger than 30 inches in diameter will be tested under Option I or II. The pipe producer shall advise the Testing Engineer in writing of the option under which the pipe will be tested. The option chosen will remain in effect until rescinded in writing.

Flared end sections and cattlepasses will be tested under Option II unless otherwise authorized by the Testing Engineer.

The specified D-load and compressive strength shall be considered as minimum and allowable failures will not apply.

Normally, neither the absorption test nor the ultimate load will be required.

708.02.3.4--Rejection. All pipe shall be subject to rejection for nonconformance to the specifications. Individual sections of pipe may be rejected for one or more of the following:

- Visible fractures or cracks, except for a single end crack that does not exceed the depth of the joint.

- Defects that indicate imperfect proportioning, mixing, and molding.

- Surface defects indicating honey-combed or open texture.

- Damaged or cracked ends which would prevent a satisfactory joint.

- Defects indicating incorrect positioning of reinforcing steel.

708.02.3.5--Repairs. Repairs will not be permitted in the barrel of the pipe. Repairs may be made on the ends, tongue and groove or bell and spigot, with an approved commercial concrete patching compound used according to manufacturer's recommendations and properly cured.

708.02.3.6--Tongue and Groove. The thickness of the tongue shall not vary

more than 1/4 inch or five percent of the wall thickness, whichever is greater, when measured at the outer edge. The thickness of the groove shall not vary more than 1/4 inch or five percent of the wall thickness, whichever is greater, when measured at a point 3/8 inch from the outer end of the groove. The depth of the groove shall not vary more than 1/4 inch from the length of the tongue.

708.02.3.7--Lift Holes. Lift holes may be formed, punched, or drilled in plastic concrete. Lift holes may be placed in cured pipe only by drilling with a diamond core-drill bit.

708.02.4--Nonreinforced Concrete Pipe. In addition to the applicable requirements of Subsection 708.02, nonreinforced concrete pipe shall meet the requirements of AASHTO Designation: M 86 for the class specified. Testing shall be in accordance with AASHTO Designation: T 280.

708.02.5--Reinforced Concrete Pipe. All reinforced concrete pipe except Class V pipe with diameters of 54 inches and larger shall meet the requirements of AASHTO Designation: M 170 as modified by Subsection 708.02.

Class V pipe with diameters of 54 inches and larger shall meet the requirements of AASHTO Designation: M 170 or M 242 as modified by Subsection 708.02 and herein.

Circular reinforced concrete pipe with S-stirrup reinforcement shall be in accordance with Figure 1 and the following requirements.

The wall thickness, amount of circular reinforcement, S-stirrup system and concrete strength shall comply with those set out in Table 1 herein. The spacing center to center of adjacent inner rings of circumferential reinforcement in a cage shall not exceed 4 inches for pipe up to and including pipe having a 4-inch wall thickness nor exceed 5½ inches for 54 inch pipe and 6 inches for all other pipe sizes.

Each line of S-stirrups shall have a continuous S shape extending longitudinally from end to end of the pipe. They shall extend from the inner cage toward the outer surface of the pipe for a distance not less than the minimum amplitude. S-stirrups shall pass around and be in contact with each inside circumferential member of the inner cage. Each line of S-stirrups shall lie essentially in a plane passing through the longitudinal axis of the pipe.

Where more than one length of stirrup material is used per line, a lap around one circumferential member of the inner cage shall be made. The ends of "S" shaped stirrups at splices shall include an outer bend. Not more than three lengths of S material may be used in a line, and the minimum length of a section of S-stirrups shall be 30 inches.

All designs in Table 1 are accepted designs with noted 0.01 inch crack and ultimate D-load.

Additional Markings. After the capital letter "D" designating the D-load, show the design wall thickness in inches expressed as a decimal. Pipe with "S" stirrups shall have the symbol S. Pipe requiring axis orientation without lift holes, i.e. stirrup pipe, quadrant reinforced pipe, shall have the center line of the crown of the pipe marked inside and outside with the symbol TB. Pipe with quadrant steel shall be marked with the symbol Q. Pipe with deformed wire reinforcement required in the design shall have the symbol DF.

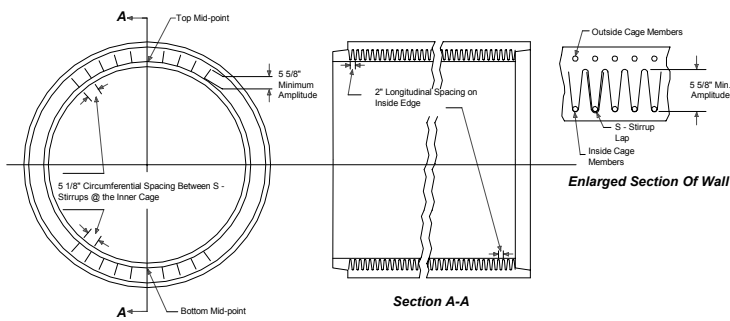


Figure 1

Illustrative Example of S-Stirrup Support System for 0.01-inch Crack D-load 3,000 102-inch Diameter Pipe, Minimum Area Per Support 0.053 Square Inch., 11 Lines Spaced @ 5 1/8 inches. For Other Classes and Sizes, See Table.

TABLE 1
0.01 Inch Crack D-Load 3,000
Ultimate Strength D-Load 3,750

Internal Diameter of Pipe	Wall Thickness	Circular Reinforcement in Circular Pipe		“S” Stirrups				
		Inner Cage	Outer Cage	Minimum Area Per Support Element	Number of Lines*	Longitudinal Spacing	Circumferential Spacing on Inner Cage	Minimum Amplitude** of Stirrups,
inches	inches	square inches per foot of pipe	square inches per foot of pipe	square inches		inches	inches	inches
Concrete Strength 5,000 Psi								
54	5 1/2	0.64	0.48	0.029	15	2	2 1/8	2 5/8
60	6	0.70	0.53	0.029	14	2	2 5/8	3 1/8
66	6 1/2	0.79	0.59	0.029	13	2	3 1/8	3 5/8
72	7	0.87	0.66	0.029	12	2	3 5/8	4 1/8
78	7 1/2	0.92	0.69	0.031	11	2	4 1/8	4 5/8
84	8	0.99	0.74	0.034	11	2	4 5/8	5 1/8
90	8	1.13	0.85	0.041	11	2	4 5/8	5 1/8
96	8 1/2	1.20	0.90	0.045	11	2	5 1/8	5 5/8
102	8 1/2	1.34	1.00	0.053	11	2	5 1/8	5 5/8
108	9	1.51	1.13	0.063	11	2	5 5/8	6 1/8
114	9 1/2	1.51	1.13	0.064	11	2	6 1/8	6 5/8
120	10	1.62	1.21	0.068	11	2	6 1/2	7 1/8
126	10 1/2	1.73	1.30	0.072	11	2	6 7/8	7 5/8
132	11	1.84	1.38	0.076	11	2	7 1/4	8 1/8
144	12	2.09	1.57	0.085	11	2	8	9 1/8

* Number of lines in the table indicates the number of longitudinal lines required in each top and bottom portion of the pipe. The area of each support element in a pipe is 2 times the cross-sectional area of the “S” stirrups wire used. There shall be an equal number of these lines of “S” stirrups on either side of the mid-point of both the top and bottom of the pipe. See Fig. 1.

** The amplitude is the overall width of the line of stirrups.

708.03--Concrete Cattlepasses. Concrete cattlepasses shall conform to the plans, the applicable requirements of Subsection 708.02, and the following: The requirements as to manufacture, materials, and curing shall conform to the requirements of AASHTO Designation: M 170. The compressive strength of the concrete shall be at least 4000 psi at 28 days.

708.04--Reinforced Concrete Flared-End Section. Reinforced concrete flared-end sections shall conform to the plans, the applicable requirements of Subsection 708.02 and the following: The requirements as to manufacturer, materials, and curing shall be the same as for the connecting pipe. The compressive strength of the concrete shall be at least 3000 psi at 28 days.

708.05--Perforated Concrete Pipe. Perforated concrete pipe shall conform to the requirements of Subsection 708.02.4 and AASHTO Designation: M 175.

708.06--Concrete Drain Tile. Standard drain tile or extra quality drain tile shall conform to the applicable requirements of AASHTO Designation: M 178.

708.07--Porous Concrete Pipe for Underdrains. Porous concrete pipe for underdrains shall conform to the requirements of AASHTO Designation: M 176.

708.08--Blank.

708.09--Blank.

708.10--Blank.

708.11--Blank.

708.12--Blank.

708.13--Blank.

708.14--Reinforced Concrete Arch Pipe. Reinforced concrete arch pipe shall meet the requirements of AASHTO Designation: M 206. Horizontal elliptical pipe may be furnished in lieu of arch pipe.

708.15--Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe. This pipe shall conform to the requirements of AASHTO Designation: M 207.

708.16--Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets. The joints shall conform to the requirements of AASHTO Designation: M 198.

708.17--Corrugated Plastic Pipe Culverts.

708.17.1--Corrugated Polyethylene Pipe Culverts. Corrugated polyethylene pipe shall conform to the requirements of AASHTO Designation: M 294, Type S.

The Contractor shall furnish to the Engineer three copies of the manufacturer's certified test reports and certification covering each shipment of pipe stating the amount furnished and that the pipe, fittings, couplings, etc. comply with the requirements of the specifications. Certifications and certified test reports for compliance with this specification shall be performed by an approved third-party testing source.

708.17.2--Corrugated Poly (Vinyl Chloride) (PVC) Pipe Culverts. Corrugated poly (vinyl chloride) (PVC) pipe shall conform to the requirements of ASTM Designation: F 949.

The Contractor shall furnish to the Engineer three copies of the manufacturer's certified test reports and certification covering each shipment of pipe stating the amount furnished and that the pipe, fittings, etc. comply with the requirements of the specifications.

708.18--Sewer Pipe Used for Underdrains.

708.18.1--General. Pipe less than four inches in diameter shall conform to commercial grade PVC water pipe.

Perforations, when required, shall be circular and conform to the requirements of AASHTO Designation: M 278.

708.18.2--Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe. This pipe and fittings used for underdrains shall meet the requirements of ASTM Designation: D 2751 for the pipe SDR number specified.

708.18.3--Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe. This pipe and fittings used for underdrains shall meet the requirements of ASTM Designation: D 3034 for the pipe SDR number specified.

708.18.4--Poly (Vinyl Chloride) (PVC) Corrugated Sewer Pipe. This pipe with a smooth interior and fittings shall conform to the requirements of ASTM Designation: F 949. The pipe is for use in non-pressure drainage applications as an alternate to ABS and PVC sewer pipe when the SDR number is specified as 35 or greater.

708.19--Corrugated Polyethylene Drainage Tubing. This tubing used for underdrains shall meet the requirements of AASHTO Designation: M 252, Type S and/or Type SP, as applicable.

708.20--Perforated Semicircular Plastic Pipe for Underdrains.

708.20.1--General. Semicircular plastic subdrain pipe is intended for direct burial and shall be extruded from thermoplastic materials as specified below. Unless otherwise specified, the pipe shall be supplied in 20-foot lengths. The pipe shall have an expanded bell on one end for direct coupling, or separate couplings shall be supplied. The pipe sections shall be joined by a friction fit.

The pipe fittings including straight couplings, end caps, tees, right laterals, left laterals, 45° elbows, and 90° elbows shall be molded from thermoplastic materials as specified below. Fabricated fittings shall be made of the same material as the pipe sections.

708.20.2--Pipe Sections and Fabricated Fittings. The pipe sections and fabricated fittings shall be made from virgin poly vinyl chloride (PVC). PVC resins shall conform to ASTM Designation: D 1784, Class 12454-B. Virgin resin is defined as resin which contains not more than 10 percent regrind material and has not previously been used to make another product.

708.20.3--Molded Fittings. Molded fittings shall be made from virgin high density polyethylene (HDPE) conforming to ASTM Designation: D 1248, Type III, Class B, Category 3; with the addition of a minimum of 0.25% carbon black.

708.20.4--Workmanship. The plastic pipe and fittings shall be homogeneous throughout and free of visible surface flaking, chips or cracks. The semicircular trough interior shall be smooth and free from obstructions. The products shall be as uniform as commercially practicable in respect to color, opacity, density and other physical properties.

708.20.5--Dimensions. The minimum wall thickness of the pipe at any point shall be 0.125 inch, protective lip excluded. Sufficient additional wall thickness shall be supplied at perforated areas to maintain an effective wall strength equal to 0.125 inch thick nonperforated wall. The protective lip shall extend a minimum of 0.500 inch from the pipe at an angle of approximately 30°. The nominal inside radius of the semicircular trough shall be 2 5/16 inch, providing a minimum cross-sectional flow area of 8.3 square inch below the water entry level. Total water intake area shall be 3.5 square inch per linear foot. All measurements shall be taken at 72 ±5°F.

708.20.6--Load Deformation. At a deflection of 0.2 inch, the minimum pipe stiffness, $F\Delta y$, shall be 100 psi when tested in accordance with ASTM Designation: D 2412, except that specimens shall be conditioned a minimum of 12 hours at approximately 72°F.

708.20.7--Impact Resistance. Impact resistance of the plastic pipe and fittings shall be as follows when tested in accordance with ASTM Designation: D 2444, except that specimens for routine inspection shall be conditioned for a minimum

of one hour at approximately 72°F or two hours at approximately 32°F.

Using a 20-pound Tup B, the plastic pipe and fittings shall be capable of withstanding 125 foot-pounds at 72°F and 62 foot-pounds at 32°F.

708.20.8--Hydrocarbon Resistance. The plastic pipe and fittings shall meet the load deformation requirements specified above after being immersed for seven days in normal heptane as specified in ASTM Designation: D 543.

708.20.9--Product Marking. Each section of pipe and each fitting shall be clearly marked on the exterior surface to show the manufacturer's name or trademark and the material from which it is made, PVC or HDPE. Product marking shall be permanent and legible in characters at least 3/8 inch high.

708.20.10--Packing and Storage. All pipe sections and fittings shall be so stored prior to shipment that they do not warp, deteriorate or suffer dimensional distortion.

All pipe sections shall be banded or palletized so as to protect them during shipment, handling and subsequent storage. Fittings shall be banded together or packed in suitable containers.

708.21--Blank.

708.22--Precast Concrete Box Culvert.

708.22.1--General. Precast concrete box culverts shall conform to the design and dimensions shown on the plans, and the materials and manufacture of box sections shall meet the requirements of AASHTO Designation: M 259 or M 273, as applicable, with the following exceptions:

708.22.2--Exceptions to AASHTO.

Cement shall meet the requirements of Section 701.

Aggregates shall meet the requirements of Subsections 703.02 and 703.03, except that gradation will not apply.

Admixtures and blends may be used with the approval of the Engineer.

Reinforcement shall meet the requirements of Subsection 711.02.3.

Water shall meet the requirements of Subsection 714.01.

A lot will consist of a group of 15 box sections of a single size or fraction thereof; or all units produced in one calendar week, Sunday through Saturday,

whichever comes first.

Each line of box section should be manufactured by one producer's plant.

The slab and wall thickness shall not vary from the design dimensions by more than five percent or 3/16 inch, whichever is greater.

The depth of cover and amount of steel may, at the discretion of the Testing Engineer, be checked by an electro magnetic device.

The permissible variation in diameter of any wire in finished fabric shall conform to the tolerances prescribed for the wire before fabrication by AASHTO Designation: M 32.

Box sections may be repaired, if necessary, because of occasional imperfections in manufacture or handling damage and will be acceptable if, in the opinion of the Engineer, the repairs are sound, properly finished, and cured and the repaired box section conforms to the specifications. These repairs will be allowed in the ends and on joints, only. No repairs will be allowed in the barrel of the box section.

708.23--Special Sections. Any special section, not otherwise specified, shall be of the same wall thickness, size, and type as the pipe to which it is joined and shall conform to the applicable requirements for the particular type of pipe as set forth therein.

Elbows, tees, wyes, or other such special sections shall, unless otherwise specified, have a minimum length for each projection sufficient to properly join the section to the joining elements of the completed structure.

Other details shall be as shown on the plans.

SECTION 709 - METAL PIPE

709.01--Cast Iron Culvert Pipe. Cast iron culvert pipe shall conform to ASTM Designation: A 716, for the wall thicknesses set out in the Tables, or as specified on the plans.

709.02--Corrugated Metal Culvert Pipe and Pipe Arches. All corrugated metal pipe and arches covered in these specifications shall conform to AASHTO Designation: M 36, except the minimum gauge thickness shall be as shown on the plans or in the contract; however, corrugated metal pipe manufactured from sheets thicker than that specified will be acceptable when approved by the Engineer. The internal diameter of corrugated metal pipe will be determined by inside measurement between the crests of the corrugations. Corrugations greater

than 3" x 1" will not be allowed in arch pipe.

709.03--Bituminous Coated Corrugated Metal Pipe and Pipe Arches.

709.03.1--Materials. Bituminous coated corrugated metal pipe and arches shall conform to the requirements of Subsection 709.02 and, in addition, shall be completely coated inside and out with an asphalt cement which will meet the performance requirements hereinafter set forth.

The pipe shall be coated uniformly to a minimum thickness of 0.05 inch, measured on the crest of the corrugations. The asphalt cement used shall be at least 99.5% soluble in carbon disulphide.

709.03.2--Performance Requirements. The asphalt cement shall adhere to the metal tenaciously, shall not chip off in handling, and shall protect the pipe from deterioration as evidenced by successfully withstanding the following tests:

709.03.2.1--Stability Test. Parallel lines shall be drawn along the valleys of the corrugations of a representative sample of coated pipe and the specimen placed on end in a constant-temperature oven with the parallel lines in a horizontal position.

The temperature of the specimen shall be maintained at a temperature of $150 \pm 2^{\circ}\text{F}$ for a period of four hours. At the end of this time, no part of any line shall have dropped more than 1/4 inch.

709.03.2.2--Imperviousness Test. The asphalt cement shall be impervious to liquids as indicated by the following tests: 25 to 50 milliliters of a 25% water solution of sulfuric acid and of a 25% water solution of sodium hydroxide shall be placed in separate corrugations for a period of 48 hours, during which time no loosening or separation of the bituminous material from the metal shall have taken place.

709.04--Bituminous Coated Paved Invert Corrugated Metal Pipe and Arches. Bituminous coated corrugated metal pipe and arches with paved invert shall conform to the requirements of Subsection 709.03 and the requirements set out below.

Bituminous material shall be applied in such a manner that a smooth pavement will result in the invert (bottom of pipe when installed) for 1/4 of the circumference of circular pipe and 40% of the circumference of pipe arches. The pavement, except where the upper edges intersect the corrugations, shall have a minimum thickness of 1/8 inch above the crest of the corrugations.

709.05--Polymer Coated Corrugated Metal Pipe and Pipe Arches. Polymer coated corrugated metal pipe and arches shall conform to the requirements of

709.02 and AASHTO Designation: M 245. The polymer precoated sheet shall be Type B with a minimum coating thickness of 0.010 inches or 0.25 millimeters on both surfaces.

709.06--Corrugated Metal Pipe for Underdrains. Corrugated metal pipe shall conform to AASHTO Designation: M 36.

709.07--Bituminous Coated Corrugated Metal Pipe for Underdrains. Bituminous coated corrugated metal pipe shall be pipe conforming to Subsection 709.06 with a bituminous coating applied in accordance with the requirements of Subsection 709.03.

709.08--Polymer Coated Corrugated Metal Pipe for Underdrains. The metal pipe for underdrains shall conform to the requirements of Subsection 709.06 and the polymer coating shall conform to the requirements of Subsection 709.05.

709.09--Corrugated Aluminum Alloy Culvert Pipe and Arches. Corrugated aluminum culvert pipe and arches shall conform to the requirements of AASHTO Designation: M 196. Minimum thickness of sheets shall be as indicated on the plans or in the special provisions.

709.10--Corrugated Aluminum Alloy Pipe for Underdrains. Corrugated aluminum pipe underdrains shall conform to the requirements of AASHTO Designation: M 196.

709.11--Bituminous Coated Corrugated Aluminum Alloy Culvert Pipe and Arches. Bituminous coated aluminum culvert pipe and arches shall conform to AASHTO Designation: M 196, and in addition shall be coated inside and out as specified in Subsection 709.03.

709.12--Bituminous Coated Paved Invert Corrugated Aluminum Alloy Culvert Pipe and Arches. Bituminous coated corrugated aluminum culvert pipe and arches with paved invert shall conform in every respect to the requirements of Subsection 709.09 and, in addition, to the requirements of Subsection 709.04 for paved invert.

709.13--Bituminous Coated Corrugated Aluminum Alloy Pipe for Underdrains. This pipe shall conform to AASHTO Designation: M 196 and shall be coated with bituminous material conforming to AASHTO Designation: M 190, type coating as specified.

709.14--Structural Plate for Pipe, Pipe Arches, and Arches. These conduits and bolts and nuts for connecting plates shall conform to AASHTO Designation: M 167.

709.15--Full Bituminous Coated Structural Plate Pipe, Pipe Arches, and

Arches. These conduits shall conform to AASHTO Designation: M 167 and shall be coated with bituminous material conforming to AASHTO Designation: M 190, type coating as specified.

709.16--Aluminum Alloy Structural Plate for Pipe, Pipe Arches, and Arches. These conduits and the bolts and nuts for connecting plates shall conform to AASHTO Designation: M 219.

709.17--Full Bituminous Coated Aluminum Alloy Structural Plate Pipe, Pipe Arches and Arches. These conduits shall conform to AASHTO Designation: M 219 and shall be coated with bituminous material conforming to AASHTO Designation: M 190, type coating as specified.

709.18--Special Sections. Any special sections, such as elbows, flared end sections, branch connections, or other specified appurtenances shall be of the same base metal, size, type, fabrication, coating, invert, and other applicable requirements as for the particular type of pipe to which it is joined.

Each elbow shall be not less than the following length:

<u>Diameter</u>	<u>Angle - Up to and Including</u>	<u>Minimum Overall Length</u>
6-inch to 48-inch	22½°	24 inches
54-inch to 84-inch	22½°	48 inches
6-inch to 36-inch	45°	24 inches
42-inch to 84-inch	45°	48 inches
6-inch to 24-inch	60°	24 inches
30-inch to 60-inch	60°	48 inches
66-inch to 84-inch	60°	72 inches
6-inch to 15-inch	90°	24 inches
18-inch to 36-inch	90°	48 inches
42-inch to 60-inch	90°	72 inches
66-inch to 84-inch	90°	96 inches

Other details shall be as shown on the plans.

All three-piece corrugated metal end sections shall have 12 gauge minimum thickness sides and 10 gauge minimum thickness center panels. Width of center panels shall be greater than 20 percent of the pipe periphery. Multiple panel bodies shall have lap seams tightly joined by three-eighths inch diameter galvanized rivets or bolts. For 60-inch thru 84-inch sizes, reinforced edges shall be supplemented with galvanized stiffener angles. The angles shall be two inches by two inches by one-quarter inch for 60-inch thru 72-inch diameters and two and one-half inches by two and one-half inches by one-quarter inch for 78-inch and 84-inch diameters. The angles shall be attached by three-eighths inch diameter galvanized nuts and bolts. For the 79-inch by 49-inch and 85-inch by

54-inch sizes, reinforced edges shall be supplemented by galvanized stiffener angles which are two inches by two inches by one-quarter inch. Angle reinforcement shall be placed under the center panel seams on the 79-inch by 49-inch and 85-inch by 54-inch sizes. A toe plate of the same materials as the end section shall be furnished and installed on each end section, unless deemed by the Engineer to be unnecessary for the particular location.

709.19--Steel Pipe and Steel Pipe Encasements. Steel pipe shall conform to the design and dimensions shown on the plans, and materials shall meet the requirements hereinafter specified.

Steel pipe with a nominal diameter of less than six inches shall meet the requirements of ASTM Designation: A 53, Type E or F, Grade A, Black, Schedule 40.

Steel pipe with nominal diameter of six inches or more shall meet the requirements of ASTM Designation: A 139, Grade A unless otherwise specified, Welded, Black, for the wall thicknesses set out in the Tables, or as specified on the plans.

Steel pipe with a nominal diameter greater than 24 inches shall be as specified on the plans.

Unless otherwise indicated on the plans, steel pipe ends shall be factory beveled for welding. The Contractor shall furnish the State Materials Engineer the original and three copies of the Mill Certificate of Compliance for all materials furnished.

SECTION 710 - PAINT

710.01--General. All paint materials, including vehicle, pigment, paste, driers, thinners, and mixed paint shall conform to the requirements of these specifications unless otherwise stipulated. Paint shall be furnished ready-mixed or in paste or powder form, as may be specified, and shall be of the type and color shown on the plans or as otherwise indicated. All paints for incorporation in the work shall be manufactured in the United States. Any paint that has caked, hardened or otherwise deteriorated shall not be used.

710.01.1--Sampling and Testing. Sampling and testing of paint shall be in accordance with the appropriate method in Federal Test Method No. 141, ASTM and/or Mississippi Test Method.

Sampling at the option of the Department will be performed at the point of manufacture or at a designated point of delivery. When the paint is sampled at the point of manufacture, the Department representative shall be given full access

to the manufacturing process.

The Central Laboratory may utilize x-ray analysis, gas chromatography, infrared, or ultra violet spectral analysis of the paint or its components to determine whether specified ingredients were used. Paint found not to be in compliance with the approved formula shall not be used.

710.01.2--Containers and Marking. Paint shall be shipped in sturdy leak proof containers. The size of the containers shall be at the option of the Contractor unless specified otherwise in the contract.

Each container or label thereon shall be marked as follows:

- Net weight in pounds
- Net volume in U. S. gallons
- Color
- Code number
- Batch number
- Name and percentage of each component
- Name and address of manufacturer
- Date of manufacture

In addition, each container and labeling thereon shall meet the requirements of State and Federal Regulations for transporting the paint.

710.02--Mixed Paints. Unless otherwise specified, paint shall be delivered completely mixed and ready for use without further additions or alterations. Paint shall be of a uniform consistency and when applied shall dry to a hard tough film without running, streaking or sagging.

All paints and components thereof shall conform to the applicable subsection as contained herein.

Mixed paint in storage shall not be exposed to temperatures less than 32°F., or such higher temperature as recommended by the paint manufacturer. Paint exposed to temperatures lower than specified will be subject to rejection or retesting.

710.02.1--Aluminum Paint. This paint shall be aluminum alkyd paint as specified by the Steel Structures Painting Council Paint Specifications SSPC 101-64T. Paint that is to be stored for periods longer than six months shall be a two component system. A two component paint shall be prepared by mixing two pounds of aluminum paste with one gallon of vehicle.

Type I Leafing Aluminum Paint shall always be used as the finish or top coat. Intermediate coats shall be alternate coats of Type II Non-Leafing Aluminum

Paint and Type I Leafing Aluminum Paint.

710.02.2--Fast Drying Acrylic Waterborne Traffic Paint. This specification covers fast drying acrylic waterborne, ready-mixed white and yellow traffic paints, Codes FDWBTW and FDWBTY.

710.02.2.1--Composition of Formulation. The composition of the paint shall be left to the discretion of the manufacturer as long as the finished product is composed of 100% acrylic emulsion, Rohm and Haas Emulsion E-2706 or Dow Chemical Emulsion DT 211NA, and meets the requirements of this specification and of any applicable Federal, State or Local regulations for products of this type.

The paint shall contain no lead, chromium, cadmium or barium. The organic yellow shall be pigment yellow C.I. #75 or #65. Rutile titanium dioxide shall be used in the yellow paint, FDWBTY.

710.02.2.1.1--Percent Pigment. The percent pigment by weight shall be not less than 45% nor more than 55%.

710.02.2.1.2--Total Non-Volatile. The paint shall have not less than 73% total non-volatiles by weight.

710.02.2.1.3--Non-Volatile Vehicle. The non-volatile portion of the vehicle shall be composed of a 100% acrylic polymer, Rohm and Haas Emulsion E-2706 or Dow Chemical Emulsion DT 211NA, and shall not be less than 44% by weight.

710.02.2.1.4--Organic Matter. The volatile content of the paint shall contain less than 150 grams of volatile organic matter per liter of total non-volatile paint material.

710.02.2.1.5--Solids Volume. The volume of solids shall be not less than 58%.

710.02.2.1.6--Weight per Gallon. The paint shall weigh a minimum of 12.0 pounds per gallon and the weight of the production batches shall not vary more than ± 0.2 pound per gallon from the weight of the qualification samples.

710.02.2.2--No Tracking Time. The paint shall dry to a no tracking condition under traffic in ninety (90) seconds maximum when applied at 15 ± 1 mil. wet film thickness and 110 to 140°F, and from three (3) to ten (10) minutes when applied at ambient temperature with six (6) pounds per gallon of Class A, Standard, glass beads or with twelve (12) pounds per gallon of Class B, High-Visibility, glass beads.

710.02.2.3--Viscosity. The consistency of the paint shall be not less than 75 nor

more than 95 Krebs Units (KU) at 77°F when tested in accordance with Federal Test Method Standard No. 141.

710.02.2.4--Flexibility. The paint shall show no cracking or flaking when tested in accordance with Federal Specification TT-P-1952.

710.02.2.5--Dry Opacity. The minimum contrast ratio shall be 0.96 when drawn with a 0.005 Bird applicator.

710.02.2.6--Daylight Reflectance. The daylight directional reflectance shall not be less than 85% for white paint and not less than 54% for yellow paint, relative to magnesium oxide, when tested in accordance with Federal Test Method No. 141.

710.02.2.7--Abrasion Resistance. No less than 180 liters of sand shall be required for removal of the paint film when tested in accordance with Federal Specification TT-P-1952.

710.02.2.8--Glass Bead Adhesion. The test for bead adhesion shall be conducted in accordance with the Abrasion Resistance Test with the exception that the test be modified to require glass beads to be uniformly applied on the paint by gravity flow at the rate of six (6) pounds per gallon for Class A, Standard, beads and 12 pounds per gallon for Class B, High-Visibility, beads. No less than 145 gallons of sand shall be required for the removal of the beaded film. The application of the glass beads is to be a separate operation, but applied at the same time as the paint.

710.02.2.9--Bleeding. The paint shall have a minimum bleeding ratio of 0.97 when tested in accordance with Federal Specification TT-P-1952. The asphalt saturated felt shall conform to Federal Specification HH-R-590.

710.02.2.10--Scrub Resistance. The paint shall pass 300 cycles minimum when tested in accordance with ASTM Designation: D 2486.

710.02.2.11--Freeze-thaw-Stability. The paint shall show no coagulation or change in consistency greater than five (5) Krebs Units, or a decrease in scrub resistance of greater than 10% when tested in accordance with Federal Specification TT-P-1952.

710.02.2.12--Dilution Test. The paint shall be capable of dilution with water at all levels without curdling or precipitation such that the wet paint can be readily cleaned up with water only.

710.02.2.13--Storage Stability. After 30 days storage in a three-quarters filled, closed container, the paint shall show no caking that cannot be readily remixed to a smooth, homogeneous state, no skinning, livering, curdling, or hard settling.

The viscosity shall not change more than five (5) Kreb Units from the viscosity of the original sample.

710.02.3.14--Acceptance Procedure. The traffic paint must be obtained from a manufacturer on the Department's "List of Approved Sources of Materials" for traffic paint manufacturers. Acceptance will be based on results of tests performed by MDOT Central Laboratory on random samples obtained from delivered batches. Certification, sampling and acceptance shall be in accordance with the requirements of MDOT S.O.P. No. TMD-30-01-00-000.

710.03--Inorganic Zinc Rich System.

710.03.1--Inorganic Zinc Primer. The shop coat or prime coat shall be a self-curing multiple component inorganic zinc rich primer conforming to the requirements of AASHTO Designation: M 300, Type I or Type II. The inorganic zinc rich primer, as applied, shall meet State and Federal regulations on Volatile Organic Compounds (VOC).

The inorganic zinc primer shall be formulated so as to produce a distinct contrast in color with the blast cleaned metal surface and the intermediate field coat to be applied thereon.

The inorganic zinc primer must be one from the Department's "List of Approved Sources of Materials."

The paint manufacturer's technical representative who is certified by the National Association of Corrosion Engineers (NACE) shall be present at the beginning of coating operations as needed to provide technical expertise in the application of the coating. This technical expertise shall be provided without additional cost to the Department. The fabricator is responsible for arranging for the presence of the manufacturer's technical representative.

710.03.2--Epoxy Mastic Field Touch-Up Paint. Inorganic zinc primer coat which has been damaged during storage, handling, transporting and/or erection shall be repaired using epoxy mastic touch-up paint prior to finish coating. Epoxy mastic touch-up paint shall be manufactured or recommended by the supplier of the inorganic zinc primer, shall be as listed on the Department's "List of Approved Sources of Materials" and, as applied, shall be VOC compliant with State and Federal Regulations.

The epoxy mastic touch-up paint shall conform to the same formulation as originally approved by the Department. Determination of conformance to the originally approved formulation will be based on physical tests and infrared spectrum. The results of these tests shall be in agreement with the results obtained on the originally approved formulation.

710.03.3--Acrylic Latex Intermediate and Top Coats, Field Coats. The acrylic latex field coats shall be manufactured by the supplier of the inorganic zinc primer coat, shall be as listed on the Department's "List of Approved Sources of Materials" and, as applied, shall be VOC compliant with State and Federal regulations. The acrylic latex paint shall conform to the same formulation as originally approved by the Department.

Determination of conformance to the originally approved formulation will be based on physical tests and infrared spectrum of the vehicle component. The infrared spectrum, 2.5 to 15 microns, of the vehicle component shall agree with the infrared spectrum of the vehicle component of the originally approved paints in both peak position and relative intensity of the peaks.

The color of the acrylic latex intermediate coat shall be white in color. The color of the acrylic latex top coat shall be light gray in color.

At the Engineer's request, the paint manufacturer's technical representative who is certified by the National Association of Corrosion Engineers shall be present at the job site at the beginning of each separate coating operation as needed to provide technical expertise in the application of the field coats. This technical expertise shall be provided without additional cost to the Department. The Contractor shall be responsible for arranging for the presence of the manufacturer's technical representative.

710.03.4--Mixing of Paint. All paint shall be mixed in accordance with the paint manufacturer's printed instructions.

710.03.5--Packaging and Marking. Multiple component paints shall be furnished in premeasured packages so as to form one unit of mixed paint when mixed with the vehicle in its container.

The containers for all paints shall be coated as necessary to prevent attack by the paint. Each container shall bear a label with the following information shown thereon: name and address of manufacturer, trade mark or trade name, kind of paint, date of manufacture and lot number, mixing instructions and equipment clean-up instructions. The VOC content shall be stated either on the label, product data sheet, or Material Safety Data Sheet.

710.03.6--Acceptance Procedure. Prior to use, the Contractor must furnish the Engineer a certificate from the manufacturer, covering each lot of paint in the shipment, attesting that the paint in the shipment conforms to the same formula as that originally approved by the Department.

Final acceptance of the paint will be based on results of tests performed by the Central Laboratory on samples obtained by the Department's representative prior to or after delivery. The use of any lot of paint prior to its final acceptance shall

be prohibited.

710.04--Epoxy Mastic System. The coating system shall consist of a modified epoxy mastic prime coat with a uniform dry film thickness of not less than five nor more than eight mils and a vinyl finish coat of not less than three nor more than five mils.

710.04.1--Prime Coat. The prime coat shall be a two-component epoxy mastic designed as a one-coat high-build complete protective coating system with excellent adhesion to rusted steel and old coating systems after such surfaces have been cleaned as specified.

710.04.1.1--Pigment. The silica and metallic aluminum pigment shall include rust inhibitors and adhesion reinforcers/ promoters. The aluminum factor shall contain both leafing and non-leafing types.

710.04.1.2--Vehicle. The vehicle shall be a modified epoxy-polyimide resin formulated to have suitable insensitivity to moisture and shall contain special wetting agents to insure adequate adhesion.

710.04.1.3--Mixed Paint. The mixed paint shall conform to the following requirements:

The catalyzed epoxy shall contain $92 \pm 2\%$ solids by weight when tested in accordance with ASTM Designation: D 1644, modified to a drying time of 72 hours at 100°F.

Total solids by volume shall be a minimum of 90%.

The coating shall air cure to a hard, tough film within five days at a temperature of 75°F. It shall be dry to the touch in 24 hours at 75°F. The usable pot life of the mixed paint shall be not less than four hours at 75°F and two hours at 90°F.

It shall exhibit good compatibility with inorganic zinc primers.

The color shall contrast with the steel and the finish coat.

The catalyzed mixture, after thinning 20% by volume with specified thinner, shall be suitable for spraying in one coat to a 10 mil wet thickness without exhibiting runs or sags.

The coating shall be suitable for application with both conventional and airless spray equipment.

710.04.1.4--Packaged Qualities. The paint shall be supplied as a two-package

material with a one-to-one mixing ratio and shall be well ground and not caked, skinned or badly settled in the container. Usable shelf life shall be not less than 12 months.

710.04.1.5--Flexibility Test. A five mil dry film thickness of paint shall be applied to one side of a 4-inch x 30-inch x 1/8-inch steel panel which has been cleaned in accordance with Steel Structures Painting Council SSPC-SP-5, Commercial Blast Cleaning. After the coating has been cured for two weeks at 75°F, it shall show no signs of cracking or loss of adhesion after the panel is uniformly bent 180 degrees (coated side out) around an eight-inch diameter pin.

710.04.1.6--Resistance Tests. A 3-inch by 5-inch by 1/8-inch test panel meeting the requirements of ASTM Designation: D 609 shall be prepared by blast cleaning in accordance with SSPC-SP-6, Commercial Blast Cleaning. After cleaning, the panels shall be exposed to the weather for 30 days to allow uniform rusting. The panels shall then be hand-cleaned with a wire brush in accordance with SSPC-SP-2.

The modified epoxy mastic paint shall be spray applied in one coat to the prepared panels with a uniform dry film thickness of six mils. Curing shall be in accordance with manufacturer's recommendations.

Each test shall be performed on one or more panels, and the paint will be unacceptable if it fails one or more of the following tests:

- (a) Salt Water Resistance. One or more panels shall be scribed with an X of at least two-inch legs down to the base metal and immersed in 5% sodium chloride at 75 ±5°F. The panel(s) shall be examined after 7, 14 and 30 days and shall show neither rusting, blistering, nor softening of the coating beyond 1/16 inch from the scribe mark. The solution shall be changed after each examining period.
- (b) Weathering Resistance. One or more panels shall be tested in accordance with ASTM Designation: G 23, Type D. The panel(s) shall be placed on test at the beginning of the wet cycle. After 1,000 hours continuous exposure, the coating shall show neither rusting, blistering, nor loss of bond.
- (c) Salt Fog Resistance. One or more panels shall be scribed with an X of at least two-inch legs down to the base metal. The panel(s) shall then be tested in accordance with ASTM Designation: B 117. After 1,000 hours continuous exposure, the coating shall show neither loss of bond, rusting nor blistering beyond 1/16 inch from the scribe mark.

710.04.2--Vinyl Finish Coat, Field Coat. The vinyl finish coat shall be manufactured by the supplier of the prime coat. The vehicle shall consist

essentially of vinyl chloride-acetate copolymer resin dissolved in aromatic or ketone and aromatic solvents. The vinyl coat shall display compatibility with, and adhesion to, the cured primer film when applied in accordance with the manufacturer's printed instructions.

710.04.2.1--Composition.

- (a) The vinyl finish coat shall be gray in color and supplied in a single package at a consistency ready for use. It shall be well ground and not caked, livered, skinned or badly settled in the container.
- (b) The vinyl finish coat shall contain not less than 29% pigment and 19% vehicle for a total of no less than 48% solids by weight. The weight per gallon shall be 9.6 ± 0.5 pounds at 77°F. The grind minimum shall be four. Any extender pigments shall be barytes.
- (c) The vinyl finish coat shall air dry at temperatures of 70°F or above to a hard tough film within four hours, entirely by evaporation of solvents. It shall be dry-to-touch in 25 minutes at 70°F.

710.04.3--Packaging. Two-component paint shall be packaged so that one unit of pigment can be mixed with the vehicle in its container. The containers for all paints shall be coated as necessary to prevent attack by the paint.

Each container shall be plainly marked with the net weight in pounds, net volume in U. S. gallons, color, code number, batch number(s), the name and address of the manufacturer and the date of manufacture. Each container, or label thereon, shall bear a true statement of the name and percentage of each component or constituent, both solid and liquid. Any package not so marked will be unacceptable.

Each shipment of paint shall be accompanied by complete written instruction and precautions for use, either on the container label or in a separate document.

710.04.4--Acceptance Procedure. Before each shipment is used, the Contractor must furnish the Engineer a certificate from the manufacturer attesting that the commercial product furnished conforms to the same formula as that previously approved.

Final acceptance will be based on results of tests performed on samples obtained by the Department prior to or after delivery. Batches of paint found not to be of the approved formulation will be rejected.

710.05--Primer for Miscellaneous Metals. The primer shall be a commercial product formulated primarily for industrial use, to combine weather durability, resistance to mildly corrosive exposures, with good film build and ease of

application with all generally used methods.

SECTION 711 - REINFORCEMENT AND WIRE ROPE

711.01--Reinforcing Steel and Wire Rope. General. All reinforcement used in concrete construction, unless otherwise stipulated, shall conform to the provisions and requirements hereinafter set out. When incorporated into the work, reinforcement shall be reasonably free of dirt, paint, oil, grease, loose-thick rust, or other foreign substances and, when deemed necessary, shall be cleaned to the satisfaction of the Engineer. Tight-thin rust or powdering rust shall not be cause to require cleaning. Reinforcement which has rusted sufficiently to cause it to fail to meet specified physical properties or prestressing strands displaying pits visible to the naked eye shall be rejected.

711.02--Reinforcing Steel.

711.02.1--Bar Reinforcement. Bar reinforcement shall conform to the requirements of AASHTO Designation: M 31, Grade 60, for billet steel bars.

Bars shall be fabricated as indicated on the plans; shall be cold-bent, unless otherwise permitted, to the shapes shown on the plans or as directed; and shall be bent prior to being wholly or partially embedded in concrete.

Unless otherwise authorized or provided on the plans, bends or hooks shall not be fabricated to a smaller diameter than that indicated for the bend test.

Rail steel bars shall be bent to the specified shapes at the mill or fabricating plant.

The areas and weights to be used in calculations for the various size reinforcing bars shall be as follows:

STANDARD REINFORCING BARS

Numbers*	Weight Pounds per Foot	Nominal Dimensions ----- Round Sections		
		Diameter Inches	Cross-Sectional Area Square Inches	Perimeter Inches
2 (1)	0.167	0.250	0.05	0.786
3	0.376	0.375	0.11	1.178
4	0.668	0.500	0.20	1.571
5	1.043	0.625	0.31	1.963
6	1.502	0.750	0.44	2.356
7	2.044	0.875	0.60	2.749
8	2.670	1.000	0.79	3.142
9 (2)	3.400	1.128	1.00	3.544
10 (2)	4.303	1.270	1.27	3.990
11 (2)	5.313	1.410	1.56	4.430
14	7.65	1.693	2.25	5.32
18	13.60	2.257	4.00	7.09

- * The bar numbers are based on the number of 1/8 inch increments in the nominal diameter of the bar, except as noted in (2) below.
- (1) No. 2 bars in plain rounds only.
 - (2) Nos. 9, 10, and 11 are round bars and equivalent in weight and nominal cross-sectional area to the old type 1-inch, 1 1/8-inch, and 1 1/4-inch square bars, respectively.

711.02.2--Bar Mats. Bar mats for concrete pavement reinforcement shall be Grade 60 billet steel, AASHTO Designation: M 31, and shall conform to the requirements of AASHTO Designation: M 54.

711.02.3--Steel Wire Fabric. Steel wire fabric shall conform to the requirements of AASHTO Designation: M 55, or AASHTO Designation: M 221.

711.02.4--Dowel Bars and Marginal Bars. Unless otherwise indicated, dowel bars used to span transverse joints and marginal bars shall be plain round bars. They shall be Grade 60 billet steel, AASHTO Designation: M 31.

Before installation, each dowel bar shall be painted with one coat of industrial grade zinc base primer, epoxy or other approved rust inhibitive primers. One half of each dowel bar shall be greased with a heavy grease equivalent to 600W or cup grease to prevent bonding with concrete. The greased end is to be inserted into the dowel bar sleeve described in the following paragraph.

Sleeves for dowel bars shall be metal or plastic of an approved design, mortar-tight, of sufficient strength to prevent collapse, and at least two inches in length.

A suitable stop shall be provided in the sleeve to permit movement of the dowel bar within the sleeve of not less than the thickness of the expansion filler used.

Dowel bars shall be free from burring or other deformations restricting slippage in the concrete.

711.02.5--Tie Bars. Unless otherwise indicated, tie bars used to span longitudinal joints shall be deformed bars, billet steel, meeting the requirements set forth in Subsection 711.02.1.

711.02.6--Cold-Drawn Steel Wire. Cold-drawn steel wire shall conform to the requirements of AASHTO Designation: M 32.

711.02.7--Supports for Bar Reinforcement. Metal bar supports shall be fabricated from stainless steel wire conforming to ASTM Designation: A 493, 16% chromium minimum, or cold-drawn wire with a minimum of 1/2 inch of the height of the leg above the form surface protected by one of the following:

Plastic coating conforming to CRSI Standards.

Galvanized, conforming to ASTM Designation: A 153, Class D.

Stainless steel conforming to ASTM Designation: A 493, 16% chromium minimum.

Other protective coating as approved by the Engineer.

Other supports as approved by the Engineer may be used.

711.02.8--Epoxy Coated Bar Reinforcement. All reinforcement bars required to be epoxy coated shall conform to the requirements of ASTM Designation: A 775. The Contractor shall furnish written certification that the coated reinforcing bars were cleaned, coated and tested in accordance with the specifications and ASTM Designation: A 775.

711.03--Reinforcement for Prestressed Concrete.

711.03.1--Pretensioning Reinforcing.

711.03.1.1--Uncoated Seven-Wire Stress Relieved Strand for Prestressed Concrete. Uncoated seven-wire stress-relieved strand for prestressed concrete shall conform to the requirements of AASHTO Designation: M 203.

711.03.1.2--Uncoated Stress-Relieved Wire for Prestressed Concrete. Uncoated stress-relieved wire for prestressed concrete shall conform to the requirements of AASHTO Designation: M 204.

711.03.2--Posttensioning Reinforcing.

711.03.2.1--Bars. Bars for posttensioning shall be of high tensile strength steel.

They shall be equipped with wedge-type anchorages which will develop the minimum specified ultimate bar stress on the nominal bar area.

The minimum physical properties of the bar steel, and of the stress-strain curve determined by static tensile tests, shall conform to the following:

Stress at 0.3% elongation, psi -----	75,000
Stress at 0.7% elongation, psi -----	130,000
Ultimate stress, psi -----	145,000
Elongation in 20 diameters, % -----	4
Modulus of elasticity, psi -----	25,000,000

The diameter tolerance of the bar steel shall be from -0.010 to +0.02375 inch.

711.03.2.2--Parallel Wire Assemblies. Wire assemblies for post-tensioning shall consist of parallel wires of the number and size shown on the plans. Wires shall conform to the requirements of AASHTO Designation: M 204. Minimum ultimate strength requirements for various sizes shall be as follows:

Diameter Inches	Minimum Ultimate Strength PSI
0.177	255,000
0.192	251,000
0.225	245,000
0.250	240,000
0.276	236,000

The stress-strain curve for wires shall show the following minimum characteristics, based on the minimum ultimate strength requirements:

Proportional limit, 0.01% offset from tangent, % -----	55
Yield point, 0.2% offset from tangent, % -----	80
Elongation at rupture -----	4% in 10 inches

The diameter tolerance of wires shall be ±0.002 inch.

711.03.3--Anchorages for Post-Tensioned Tendons.

711.03.3.1--For Bars. Wedge-type anchorages shall be used for bars. The wedge device shall develop the minimum ultimate strength specified for the nominal bar area.

Wedge anchorages shall bear against anchor plates fabricated of hot-rolled steel having physical characteristics not less than that specified for No. 104 of American Iron and Steel Institute (AISI) Specifications.

711.03.3.2--For Parallel Wire Assemblies. Wedge or direct-bearing type anchorage shall be used, generally. The anchorage device shall be capable of developing the ultimate strength of the total number of wires anchored. Conical type anchorages shall be embedded within the ends of the concrete members unless otherwise specified. Anchorages shall generally bear against grids of reinforcing steel of approved type.

711.03.3.3--Alternate Anchorage Types. Alternate anchorage types conforming to the general physical requirements for wedge or direct-bearing type anchorages will be permitted. All anchorage types shall develop the specified ultimate strength of the reinforcing tendons, or the allowable stress of the tendon will be based on the anchorage strength.

As a specific exception, threaded anchorages not on upset or oversize reinforcing ends will not be considered for approval.

Any alternate type anchorage, before being considered, will be required to show evidence of being capable of withstanding at least 3,000,000 cycles of twice the maximum live load stress variation.

711.03.4--Tests for Prestressing Reinforcing. The Engineer shall be furnished with three certified copies of test results for all tests specified below. These tests shall be performed by the manufacturer or a recognized commercial laboratory at no additional cost to the State. The Engineer or Engineer's representative shall have the privilege of witnessing any or all tests.

711.03.4.1--Strand. The physical characteristics of strand shall be determined in accordance with AASHTO Designation: M 203.

711.03.4.2--Bars.

711.03.4.2.1--Proof Test. During manufacture, each bar shall be proof tested to a minimum stress of 130,000 psi.

711.03.4.2.2--Static Test. From each mill heat, one static test shall be made on an assembled bar and anchorage to determine the physical properties of the steel and the assembly. Such physical properties shall conform to the minimum physical properties hereinbefore specified.

711.03.4.3--Wires and Wire Anchorages. One static test shall have been made from each five coils received, except that at least one static test shall have been made for each shipment. For each 500 anchorages received, or fraction thereof, one anchorage assembly shall have been tested statically to destruction.

SECTION 712 - FENCE AND GUARDRAIL

712.01-- General. Each of the several items included under this section shall be of the design, shape, size, and dimensions shown on the plans or set out in these specifications. The connections with all intersecting fences, bridges, and culvert headwalls shall be as shown on the plans.

712.02--Barbed Wire. Barbed wire shall be composed of two strands of No. 12½ gauge wire with round barbs, four-point pattern, conforming to ASTM Designation: A 121. In the coastal counties of Hancock, Harrison, and Jackson, Class 3 zinc coating shall be furnished. Class 1 or better zinc coating shall be furnished for all other areas of the State.

In lieu of the above, the Contractor may furnish high tensile strength barbed wire. If the Contractor elects to furnish high tensile strength barbed wire, it shall meet the requirements of ASTM Designation: A 121 with the following exceptions:

The coated line wires shall have a nominal diameter of 0.067 inch. The coated barbs shall have a nominal diameter of 0.057 inch.

The minimum weight of zinc coating shall be 0.75 ounce per square foot for the line wire and 0.70 ounce per square foot for the barbs.

The line wire shall have a minimum strength of 475 pounds per individual strand.

712.03--Woven Wire Fencing. Woven wire (hog wire) fencing shall conform to the requirements of ASTM Designation: A 116. In the coastal counties of Hancock, Harrison, and Jackson, Class 3 zinc coating shall be furnished. Class 1 or better zinc coating shall be furnished for all other areas of the State.

712.04--Chain Link Fence. Details will be shown on the plans or in the special provisions. Chain link fencing shall conform to the requirements of AASHTO Designation: M 181 with the following clarifications and exceptions:

Zinc coated chain link fabric for use in Hancock, Harrison, and Jackson counties shall meet the requirements for Class D spelter coating. For all other areas of the State, the spelter coating shall meet the requirements for Class C coating.

Tie wire shall conform to the requirements of Subsection 712.13.

Tension wire shall conform to the requirements of Subsection 712.14.

Posts, rails, expansion sleeves, and gate frames shall conform to the requirements for posts in Subsection 712.05.2, unless otherwise designated in

the contract.

Miscellaneous fittings and hardware shall conform to the requirements of Subsection 712.16.

The Contractor shall furnish the Engineer with manufacturer's or fabricator's test results and other data certifying that materials furnished for construction of all types of chain link fence comply with the requirements set out in these specifications. The Engineer reserves the right to retest all materials.

712.05--Fence Posts and Braces.

712.05.1--Treated Timber Posts and Braces.

712.05.1.1--General. All wood posts and braces shall be Southern Pine and shall be furnished in the sizes shown on the plans or as otherwise specified.

Insofar as practicable, each charge shall consist of pieces approximately equal in size, moisture, and sapwood content into which approximately equal quantities of preservative can be injected. Each layer of material shall be separated at each end, and at the center when necessary, by strips at least 3/8 inch in thickness.

All wood posts and braces shall be treated in accordance with AWWA C 14, except the type of preservative shall conform to Subsection 718.04. Only one type of preservative shall be used for the treatment of materials for any one class of construction on a project, unless otherwise specified.

Posts and braces will not be accepted for use unless they have been inspected by an authorized representative of the Department and found to be satisfactory both before and after treatment. Inspection prior to treatment may be waived by the State Materials Engineer when the preservative will be pentachlorophenol or chromated copper arsenate.

Inspection for conformance to these specifications will be conducted in accordance with Department Standard Operating Procedures. Borer cores for determining the amount of preservative retained and the penetration of preservative will be obtained in accordance with Standard M2. The test method for determining the amount of preservative retained will be either as specified in AWWA or Mississippi Test Methods. All borings shall be taken at the center of the narrow side of the piece. Test holes shall be plugged with treated plugs. If 20% or more of the borings from a charge of treated material fail to meet the penetration requirements, the entire charge shall be rejected and subject to retreatment. If upon retreatment, the material meets the penetration requirements it will be accepted provided all other characteristics conform to the specifications. Only one retreatment will be permitted, and any apparent damage due to retreatment shall be cause for rejection.

The Department shall be notified sufficiently in advance of treating the material so that an inspector may be furnished at the plant to inspect the material and the treatment of same. All materials and processes used in the manufacture of the materials shall be subject to inspection. The plant shall be equipped with the necessary gauges, thermometers, appliances, and facilities to enable the inspector to determine the conditions at all stages of the treatment and to satisfy the inspector that the requirements of the specifications are fulfilled. The manufacturer shall also provide the apparatus and chemicals necessary for making tests at the plant as required by the Department. All equipment, apparatus, etc., shall be maintained in proper and satisfactory condition for use at all times.

712.05.1.2--Round Posts. Unless otherwise indicated, wood line posts shall be round, shall be cut from sound and solid trees, and shall be free from short or reverse bends in more than one plane. A straight line from center of tip to center of butt shall not deviate outside the post. Posts shall be free of ring shake, season cracks more than 1/4 inch wide, splits in the end, and unsound knots. Sound knots will be permitted provided the width of the knot does not exceed 1/3 the diameter of the post at the point where it occurs. Groups of knots or any combination of defects impairing the strength more than the maximum size knot will not be permitted. The posts shall show not less than three annual rings per inch, and not less than 30% of summer wood.

The size of round posts will be specified in even inches of diameter at the top (smaller) end and shall not vary more than 1/2 inch from the specified diameter; i.e., nominal four-inch posts may vary between 3 1/2 inches and 4 1/2 inches; nominal six-inch posts may vary between 5 1/2 inches and 6 1/2 inches. This diameter shall be determined from the circumference after peeling. In the case of ovate (not true round) posts, the maximum diameter shall not be more than 20 percent greater than the minimum diameter, direct measure. The maximum allowable increase of diameter at the butt shall be at the rate of 1 1/2 inches in 10 feet. A tolerance of ± 2 inches will be allowed in the specified length.

Prior to treatment, round posts shall be machine peeled for their full length, with all bark and inner skin removed and all knots or projections trimmed flush with the surface of the surrounding wood. The ends shall be sawed square. Treatment shall be in accordance with AWP Standard C14.

712.05.1.3--Sawed Posts. Sawed fence posts shall conform to the shape and nominal dimensions shown on the plans. They shall be No. 1 or better, graded in accordance with American Lumber Standards. Treatment will be in accordance with AWP Standard C14.

712.05.1.4--Sawed Braces. Sawed braces shall conform to the shape and nominal dimensions shown on the plans. They shall be No. 1 or better, graded in accordance with American Lumber Standards. Treatment will be in accordance

with AWP Standard C14.

712.05.2--Metal Posts. All metal posts shall be of the size and configuration specified on the plans.

712.05.2.1--Round Steel Posts. Round steel posts shall be galvanized steel pipe, coated inside and out, meeting the requirements of ASTM Designation: F 1083. Schedule 40 shall be applicable unless otherwise specified in the contract. Round steel posts meeting the following specifications will be acceptable alternates to those meeting the requirements of ASTM Designation: F 1083, Schedule 40.

712.05.2.1.1--Method of Manufacture. The pipe shall be manufactured by cold rolling electric resistance welding of high strength steel having a minimum yield strength of 50,000 psi conforming to ASTM Designation: A 653 or A 1011. The exterior surface of the pipe shall be triple coated with hot-dip galvanized zinc followed by a chromate conversion coating and a urethane or polyurethane acrylic top coating. The interior surface of the pipe shall be given corrosion protection by zinc rich organic coating or a hot-dipped galvanized zinc coating.

712.05.2.1.2--Pipe Size and Weight. The pipe shall meet the following nominal requirements for outside diameter, wall thickness and weight per linear foot:

NPS Designator Inside Diameter	Outside Diameter	Wall Thickness	Weight per foot
<u>Inches</u>	<u>Inches</u>	<u>Inches</u>	<u>pounds</u>
1¼	1.660	0.110	1.820
1½	1.900	0.120	2.281
2	2.375	0.130	3.117
2½	2.875	0.160	4.640

NOTE: Allowable tolerances from the above dimensions and weight per foot are as follows:

Outside Diameter:	±1.0%
Wall Thickness:	-5.0%, No limit on plus
Weight per Foot:	±5.0%

712.05.2.1.3--Pipe Strength. The strength of the pipe shall be the product of the yield strength and the section modulus, and shall not be less than that of pipe of equivalent diameter conforming to ASTM Designation: F 1083, Schedule 40.

712.05.2.1.4--Protective Coatings. The protective coatings shall conform to the requirements of AASHTO Designation: M 181 for Grade 2 posts and rails with hot-dip galvanized zinc plus organic exterior coatings.

712.05.2.2--Steel Tee Posts. Steel tee posts shall meet the requirements of

ASTM Designation: A 702, galvanized in accordance with the requirements of ASTM Designation: A 123.

Acceptance of the steel posts shall be by certification from the manufacturer, producer, supplier, or fabricator, as applicable.

712.05.2.3--Steel H-Beam Posts. Steel H-Beam posts shall be produced from structural quality weldable steel having a minimum yield strength of 45,000 psi and shall be galvanized in accordance with ASTM Designation: A 123. Steel H-Beam line posts shall be 2.250 inches by 1.625 inches and shall weigh 3.43 pounds per foot. A tolerance of plus or minus 5.0 percent is allowed for weight per foot. A tolerance of plus or minus 1.0 percent is allowed for dimensions.

712.05.2.4--Aluminum-Alloy Posts. Round aluminum-alloy posts shall meet the requirements of ASTM Designation: B 241, Alloy 6061, T6.

Aluminum-Alloy H-Beam posts shall meet the requirements of ASTM Designation: B 221, Alloy 6061, T6.

712.05.2.5--Formed Steel Section Posts. Formed steel section posts, "C" sections, shall be formed from sheet steel conforming to ASTM Designation: A 1011, Grade 45, and shall be galvanized in accordance with ASTM Designation: A 123. The posts shall meet the dimensions and weight per linear foot set-out below. A tolerance of plus or minus 5.0 percent is allowed for weight per foot. A tolerance of plus or minus 1.0 percent is allowed for dimensions.

<u>Size, Inches</u>	<u>Weight, Pounds Per Foot</u>
1.625 X 1.250	1.35
1.875 X 1.625	1.85
2.250 X 1.700	2.78
3.500 X 3.500	5.10

712.05.3--Concrete Posts.

712.05.3.1--Manufacture. Concrete posts shall be manufactured in accordance with the details shown on the plans and shall conform to the requirements hereinafter set forth. Posts shall receive a Class 1 finish as noted in Subsection 804.03.19. Where indicated on the plans, holes and bolts shall be accurately cast in the members at the time of pouring. Posts shall be cured at least seven days.

712.05.3.2--Materials. The materials used in the manufacture shall conform to the following:

Cement shall meet the requirements of Section 701.

Aggregates shall meet the requirements of Subsections 703.02 and 703.03, except that the requirements for gradation are not applicable.

Reinforcing steel shall meet the requirements of Section 711.

The concrete shall have a minimum cement factor of 1.25, or five bags of cement to a cubic yard of concrete.

712.05.3.3--Strength Requirements. The strength of concrete posts shall be determined by the beam method. When loaded at the midpoint of an 18-inch span with three edge bearing, the unit shall develop at least 6,000 pounds total load for a four-inch by four-inch post; or 12,000 pounds total load for a six-inch by six-inch post.

Two specimens will be tested for each 200 posts, one to destruction and one to the ultimate load specified above.

712.06--Guard and Guardrail Posts.

712.06.1--General. Unless otherwise specified, guardrail posts may be either wood or steel, and guard posts may be either wood, steel, or concrete. All guardrail and guard posts materials shall conform to the dimensions and requirements as shown on the plans or as set out in these specifications.

712.06.2--Treated Wood Posts. Treated wood posts shall conform to the size and dimensions as shown on the plans and as hereinafter specified.

712.06.2.1--Square Posts. All square posts shall be inspected in accordance with Section 718 except that the posts may be rough and shall be within $\pm 3/8$ " of the dimensions shown on the plans. Treatment will be in accordance with AWPAC Standard C14.

712.06.2.2--Round Posts. All round posts shall be inspected and treated in conformity with 712.05.1 and shall be of the shape and dimensions as shown on the plans.

712.06.3--Concrete Posts. Concrete posts shall conform to the requirements of Subsection 712.05.3.

712.06.4--Steel Posts. Steel posts shall be of the section and length as shown on the plans and shall conform to the requirements of ASTM Designation: A 36.

The posts shall be galvanized or shop-painted as specified.

712.06.5--Treated Wood Blocks For Use With Metal Guardrail Posts. Treated wood blocks for use with metal guardrail posts shall be within $\pm 3/8$ -inch

of the size and dimensions shown on the plans, except that a minus tolerance shall not be allowed for the slotted width in which the metal post must fit. Preservative treatment shall be in accordance with AWWA Standard C14.

The blocks must be obtained from approved manufacturers listed on MDOT's "Approved Sources of Materials" for suppliers of treated wood products. The manufacturer's approval will be based on their Quality Control Program for material certification. The manufacturer shall employ a certified material grader and treatment inspector who will be responsible for grading and inspecting the treated material. The inspector's certification shall be from an approved industrial organization such as AWWA, SPIB or American Lumber Standard. The manufacturer's certification shall be based on satisfactory grading, dimensional measurements, and treatment results. The manufacturer shall provide the Contractor two copies of their material certification and treatment report for each charge of material delivered. Also, a copy of these documents shall be mailed to the State Materials Engineer for all blocks shipped for use on MDOT projects.

The manufacturer shall brand each block with the following information:

- (1) manufacturer's logo or initials (XYZ)
- (2) manufacturer's plant location
- (3) species of wood (SYP)
- (4) treatment type (CCA-C)
- (5) minimum preservative retention by assay (0.50)

The Contractor, prior to installation of the blocks, shall furnish a copy of the manufacturer's certification and treatment report covering the blocks to be installed to the Department's representative.

The Project Engineer, or the Project Engineer's designated representative, will inspect each block prior to installation for proper dimensions, identification and damage or other deficiency prior to permitting installation of the blocks. The Project Engineer will notify the State Materials Engineer when blocks are delivered to the project and report any deficiencies found. The State Materials Engineer will, at the State Materials Engineer's discretion, dispatch an inspector to the project for inspecting and boring the blocks for an assay test. Final acceptance of the blocks will be based on satisfactory field inspection and satisfactory test results when field sampling is performed.

712.07--Metal Rail. Metal rail for guardrail shall conform to the requirements of AASHTO Designation: M 180 and as specified on the plans.

712.08--Timber Rail. Timber rail shall conform to the requirements of Section 718 and as specified on the plans.

712.09--Guardrail Hardware. Guardrail hardware such as bolts, nuts and washers shall conform to the requirements of ASTM Designation: A 307 except specified bolts, as shown on the plans, shall meet the requirements of ASTM Designation: A 325 or AASHTO Designation: M 164. Galvanizing may be hot-dipped or by a mechanical method all in accordance with ASTM Designation: A 153, except for method of coating.

712.10--Box Beam Rail. Steel beam rail elements shall conform to the requirements of ASTM Designation: A 500 or ASTM Designation: A 501 and shall be galvanized after fabrication in accordance with AASHTO Designation: M 111, except when corrosion resistant steel rail elements are specified; in which case rail elements shall be made of steel meeting the dimensional and mechanical requirements of ASTM Designation: A 500 or ASTM Designation: A 501, shall have an atmospheric corrosion resistance approximately two times that of carbon structural steel with copper, and shall not be painted or galvanized. Posts shall conform to Subsection 712.06 and hardware to Subsection 712.09.

712.11--Guardrail Cable and Anchorage. Cable shall meet the requirements of AASHTO Designation: M 30 for Type II wire rope.

The anchor rod shall be fabricated of steel conforming to the requirements of ASTM Designation: A 36. The eye may be drop forged or formed with a full penetration weld and shall develop 100 percent of the rod strength.

The swaged fitting and stud assembly shall be of steel conforming to the requirements of ASTM Designation: A 576, Grade 1035 and shall be annealed and suitable for cold swaging. The fitting shall be galvanized in accordance with ASTM Designation: A 123 before swaging. The studs shall conform to the requirements of ASTM Designation: A 449 and shall be galvanized as set forth for guardrail hardware. The swaged fitting, stud and nut shall develop the breaking strength of the wire rope. Three certified copies of the manufacturer's certificate attesting to the strength of the swage fittings shall be furnished the State Materials Engineer.

712.12--Gates.

712.12.1--Slatted Aluminum Gates. Slatted aluminum gates shall be of the design and dimensions as shown on the plans. Members, parts, and accessories shall be formed of an aluminum alloy having a high resistance to corrosion. Minimum nominal thickness of members shall be 0.051 inch for horizontals and 0.040 inch for diagonals and verticals.

Aluminum gates shall be tightly riveted construction and after erection shall not show any sag or warp. The gates shall be equipped with satisfactory hinge supports and latch or aluminum chain with steel snap.

712.12.2--Galvanized Ferrous Metal Gates. Galvanized ferrous metal gates shall be of the design and dimensions as shown on the plans. The gates shall be fabricated from 24-gauge or heavier metal with rigid construction, and after erection the gates shall not show any sag or warp. Steel sheets used in fabricating gates shall be hot dip galvanized in accordance with ASTM Designation: A 653, G 60 Coating Designation.

712.12.3--Aluminum-Zinc Alloy Coated Metal Gates. Aluminum-zinc alloy metal gates shall be of the design and dimensions as shown on the plans. The gates shall be fabricated from 24-gauge or heavier metal with rigid construction, and after erection the gates shall not show any sag or warp. Steel sheets used in fabricating gates shall be coated with an aluminum-zinc alloy by the hot-dip process. The coating shall have a nominal chemical composition of 55.0% aluminum, 43.4% zinc and 1.6% silicon. The chemical analysis of the coating shall agree with the nominal composition within $\pm 3\%$ for aluminum and zinc, and within $\pm 0.5\%$ for silicon. The minimum weight of coating shall be 0.5 ounce per square foot total both sides when tested in accordance with AASHTO Designation: T 65.

712.12.4--Aluminum Coated Metal Gates. Aluminum coated metal gates shall be of the design and dimensions as shown on the plans. The gates shall be fabricated from 24-gauge or heavier metal with rigid construction, and after erection shall not show any sag or warp. Steel sheets used in fabricating gates shall be coated with aluminum by the hot-dip process. The coating shall meet the chemical requirements of AASHTO Designation: M 274. The minimum weight of coating shall be 0.4 ounce per square foot total both sides when tested in accordance with AASHTO Designation: T 213.

712.12.5--Fabric Filled Gates. The gate frame shall be constructed from pipe meeting the requirements of ASTM Designation: F 1083, Schedule 40, and to the design and dimensions as shown on the plans. All connections shall be welded and watertight. The entire frame shall be hot dip galvanized after welding.

712.12.6--Acceptance Procedure. The Contractor shall furnish the Engineer three copies of the manufacturer's certification attesting that the gates furnished comply with the requirements of the contract.

712.13--Tie Wire. Tie wire shall be of good commercial quality zinc coated steel, aluminum coated steel or aluminum alloy of the size and spacing shown on the plans. Zinc coated steel wire shall meet the spelter coating requirements of AASHTO Designation: M 279, Class 1. Aluminum coated steel wire shall be coated with aluminum meeting the requirements of AASHTO Designation: M 181 and at the rate of not less than 0.4 ounces per square foot of uncoated area.

712.14--Tension Wire. Tension wire shall be of the same material as the fencing wire being used, shall be of good commercial quality, and shall meet the

following requirements for the specified type wire being used.

712.14.1--Zinc Coated Tension Wire. The base metal of zinc coated tension wire shall be steel wire having a minimum tensile strength of 60,000 psi and shall meet the spelter coating requirements of AASHTO Designation: M 279, Class 1.

712.14.2--Aluminum Coated Tension Wire. The base metal of aluminum coated tension wire shall be steel wire having a minimum tensile strength of 60,000 psi and shall be coated with aluminum meeting the requirements of AASHTO Designation: M 181 for aluminum coating and at the rate of not less than 0.4 ounces per square foot of uncoated area.

712.14.3--Aluminum Alloy Tension Wire. Aluminum alloy tension wire shall have a minimum tensile strength of 42,000 psi.

712.15--Staples. Unless otherwise specified, staples shall be made of 9-gauge galvanized steel wire and shall be of the shape and size shown on the plans. The galvanizing shall be commercial quality uniformly applied zinc coating.

712.16--Hardware. All ferrous metal hardware for fencing such as bolts, nuts, washers, and metal straps shall be as specified on the plans and galvanizing shall not be less than 1.0 ounce per square foot of uncoated area. Aluminum coated hardware shall be coated with aluminum meeting the requirements of AASHTO Designation: M 181 for aluminum coating and at the rate of not less than 0.4 ounces per square foot of uncoated area.

Aluminum alloy hardware shall conform to the requirements of ASTM Designation: B 221 for extruded aluminum alloy 6063, T6. The finished members shall be of uniform quality.

Aluminum-zinc coated hardware shall be coated with an aluminum-zinc alloy meeting the chemical requirements and weight of coating specified for aluminum-zinc alloy coated metal gates.

SECTION 713 - CONCRETE CURING MATERIALS AND ADMIXTURES

713.01--Curing Materials. Concrete curing agents, including water and earth, shall be free of any ingredients which may damage or be detrimental to the concrete. Such agents, unless otherwise specified, shall conform to the requirements hereinafter set forth.

713.01.1-Burlap Cloth. Burlap to be used for curing concrete shall conform to the requirements of AASHTO Designation: M182.

Class 3 burlap shall be used by placing one or two layers as required. The substitution of other classes may be made, provided their combined weight will equal or exceed the weight required.

713.01.2--Liquid Membrane Compound. Membrane-forming compound for curing concrete shall conform to the requirements of AASHTO Designation: M 148.

Unless otherwise specified, only Type 2, White Pigmented, will be permitted for use.

The use of liquid membrane for curing concrete surfaces which are to have a rubbed finish or faces of construction joints will not be permitted.

713.01.3--Polyethylene Sheeting. White polyethylene sheeting shall conform to the requirements of AASHTO Designation: M 171 for white opaque polyethylene film.

713.02--Admixtures for Concrete. Air-entraining admixtures used in portland cement concrete shall comply with AASHTO Designation: M 154. Set-retarding, accelerating, and/or water-reducing admixtures shall comply with AASHTO Designation: M 194.

In order to obtain approval of an admixture, the State Materials Engineer shall have been furnished certified test reports, made by an acceptable independent laboratory regularly inspected by the Cement and Concrete Reference Laboratory of the National Bureau of Standards, which show that the admixture meets all the requirements of the applicable AASHTO Standard Specification.

The Department reserves the right to sample, for check tests, any shipment or lot of admixture delivered to a project.

The Department reserves the right to require tests of the material to be furnished, using the specific cement and aggregates proposed for use on the project, as suggested in AASHTO Designation: M 154 and outlined in AASHTO Designation: M 194.

After an admixture has been approved, the Contractor shall submit to the State Materials Engineer, with each new lot of material shipped, a notarized certification from the manufacturer showing that the material is of the same composition as that originally approved, and that the material has not been in any way changed or altered.

Admixtures containing chlorides will not be permitted.

Failure to maintain compliance with any requirement of these specifications shall be cause for rejection of any previously approved source or brand of admixture.

When an admixture is used in portland cement concrete, it shall be the responsibility of the Contractor to produce satisfactory results.

SECTION 714 - MISCELLANEOUS MATERIALS

714.01--Water.

714.01.1--General. All water used shall be free from injurious quantities of oil, acid, alkali, or vegetable matter; shall be reasonably clear; and shall not be brackish. If at any time water from source becomes of unsatisfactory quality or of insufficient quantity, the Contractor shall provide satisfactory water from some other source. Where the source of water is relatively shallow, the Engineer may require the intake to be so enclosed as to exclude silt, mud, grass, or other foreign materials.

Requirements for impurities set out in these specifications are general maximums which may be used as a basis for acceptance. However, if the preliminary analysis indicates that any of the specified limits for acidity or alkalinity, organic solids, or inorganic solids are exceeded, the water may be further tested as provided in Subsection 714.01.6 to determine its suitability for the purpose intended.

714.01.2--Water for Use in Concrete. Water used in mixing of concrete, mortar, and grout shall be as set out above. In addition, the water shall not contain impurities in excess of the following limits:

Acidity or alkalinity, calculated in terms of calcium carbonate, % -----	0.05
Total organic solids, % -----	0.05
Total inorganic solids, % -----	0.05

The tests for organic solids and inorganic solids may be waived by the State Materials Engineer on water samples from ponds, lakes, streams, rivers, and ditches in all except the following counties: Pearl River, Stone, George, Hancock, Harrison, and Jackson Counties.

714.01.3--Water for Use in Chemically Stabilized Base. Water used in the construction of bases which contain cement, lime, or other chemical additive shall be as set out in Subsection 714.01.1 and, in addition, shall not contain impurities in excess of the following limits:

Acidity or alkalinity, calculated in terms of calcium carbonate, % -----	0.05
Total organic solids, % -----	0.05
Total inorganic solids, % -----	0.20

The tests for organic solids and inorganic solids may be waived by the State

Materials Engineer on water samples from ponds, lakes, streams, rivers, and ditches in all except the following counties: Pearl River, Stone, George, Hancock, Harrison, and Jackson Counties.

714.01.4--Water for Use in Granular Base. Water for use in granular bases may be brackish.

714.01.5--Water for Use in the Planting and Establishment of Vegetation. Water used for planting and establishment of vegetation shall meet the requirements of Subsection 714.01.1 as related to injurious quantities of oil, acid, or alkali and shall not be brackish.

714.01.6--Tests. As applicable, a routine analysis of the sample of water submitted will be made. If the routine analysis indicates that any of the specified limits for acidity or alkalinity, organic solids, or inorganic solids are exceeded, the water may be further tested by either or both of the following methods as determined by the State Materials Engineer:

1. A chemical analysis to determine the nature of the specified characteristics for which minimum values are established.
2. Strength and Time-of-Set Test. Results of additional tests may be considered satisfactory if:
 - (a) the solids are found to be not detrimental to the materials with which the water is used;
 - (b) the alkali carbonates and bicarbonates do not exceed 0.1% by weight of water when the combination of carbonates and bicarbonates is calculated to sodium carbonate, Na_2CO_3 ;
 - (c) the 28-day strength of mortar made with the water is not less than 90% of that made with distilled water; and
 - (d) the time of set is not less than 45 minutes.

In general, water will be approved if it complies with the applicable requirements of the Standard Specifications, or if the results of additional tests as provided above are determined by the State Materials Engineer to be satisfactory.

No formal tests of water used for granular base, or embankment construction, or in connection with the planting and establishment of vegetation will be made unless the Engineer questions the quality of the water.

714.02--Calcium Chloride. Calcium chloride shall conform to the requirements of AASHTO Designation: M 144. Calcium chloride shall not be used in concrete which will be prestressed; nor shall it be used in other concrete unless specifically approved by the Engineer.

714.03--Lime.

714.03.1--General. Lime shall be stored and handled in closed, weather-proof containers until used. If local storage is provided, lime shall be used only from approved storage facilities and shall meet the requirements of the contract at the time of use.

714.03.2--Hydrated Lime. Hydrated lime for use in mortar shall conform to the requirements of ASTM Designation: C 207, Type N.

Hydrated lime for soil stabilization shall conform to the following requirements:

Calcium and magnesium oxides, nonvolatile basis, %, minimum -----	90
Carbon dioxide, %, maximum -----	7
Moisture loss, 2 hours @ 120°C, maximum -----	3

Gradation of Residue:	
Retained on No. 30 sieve, %, maximum -----	2.5
Retained on No. 200 sieve, %, maximum -----	15

714.03.3--Quick Lime.

714.03.3.1--Granular or Pelletized Quick Lime. Granular or pelletized quick lime for soil stabilization shall be a commercial granular or pelletized quick lime and shall conform to the following requirements prior to slaking:

Calcium and magnesium oxides, nonvolatile basis, %, minimum -----	90
Carbon dioxide, %, maximum -----	7
Gradation, percent passing by weight:	
¾ inch sieve -----	100
No. 4 sieve -----	0-30

The Contractor shall furnish certified test reports with each shipment of quick lime attesting to the purity of the lime and that the lime meets the requirements of the specifications; however, the material shall be subject to inspection, test, or rejection by the Engineer at any time

714.03.3.2--Dry Quick Lime. Dry quick lime used for soil stabilization by the dry application method shall be a commercial quick lime and shall conform to the following requirements after two minutes on a Ro-tap shaker:

<u>Sieve</u>	<u>Percent Passing By Weight</u>
No. 10	100
No. 20	90 - 100
No. 100	0 - 20
No. 200	0 - 5

Dry quick lime shall meet the slaking standards as defined in ASTM Designation: C 110, and shall reach maximum heat rise in no more than six (6) minutes.

The Contractor shall furnish certified test reports with each shipment of quick lime attesting to the purity of the lime and that the lime meets the requirements of the specifications; however, the material shall be subject to inspection, test, or rejection by the Engineer at any time.

714.03.4--Bag Lime. When bag lime is used, the bag shall bear the weight certified by the manufacturer. Bags varying more than five percent from the certified weight will be rejected, and the average weight of bags in any shipment determined by weighing 50 bags taken at random shall not be less than the certified weight. Bag lime shall conform to the requirements of hydrated or quick lime as applicable.

714.03.5--Limestone Dust. The source of the material shall be approved by the Engineer and meet the following gradation requirements:

<u>Sieve</u>	<u>Percent Passing</u>
No. 30	95 - 100
No. 200	20 - 100

714.04--Sodium Chloride. Sodium chloride shall conform to the requirements of AASHTO Designation: M 143.

714.05--Fly Ash.

714.05.1--General. The fly ash source must be approved for listing in the Department’s “Approved Sources of Materials” prior to use. The acceptance of fly ash shall be based on certified test reports, certification of shipment from the supplier and tests performed on samples obtained after delivery in accordance with the Department SOP.

Different classes of fly ash or different sources of the same class shall not be mixed or used in the construction of a structure or unit of a structure without written permission from the Engineer.

The Contractor shall provide suitable means for storing and protecting the fly ash from dampness. Fly ash which has become partially set or contains lumps of caked fly ash shall not be used.

The temperature of the bulk fly ash shall not be greater than 165° at the time of incorporation into the work.

In addition to these requirements, fly ash shall meet the following specific

requirements for the intended use.

714.05.2-Fly Ash for Use in Concrete. When used with portland cement in the production of concrete or grout, the fly ash shall meet the requirements of AASHTO Designation: M 295, Class C or F, with the following exceptions:

The loss on ignition shall not exceed 6.0 percent.

The pozzolanic activity index with portland cement shall be at least 55 percent of the control mix at seven days. The water requirement shall not exceed 105 percent of the control mix.

Fly ash shall not be used with portland cement Type IP.

714.05.3-Fly Ash for Soil Stabilization. When used with hydrated lime in soil stabilization, the class of fly ash shall be as specified in the contract. The fly ash, when mixed with hydrated lime and soil or soil-aggregate, shall produce the minimum design characteristics for the course to be stabilized. The fly ash shall meet the requirements of AASHTO Designation: M 295 for the class specified, except the loss on ignition shall not exceed 10.0 percent.

714.06--Ground Granulated Blast Furnace Slag (GGBFS).

714.06.1--General. The GGBFS source must be approved for listing in the Department's "Approved Sources of Materials" prior to use. The acceptance of GGBFS shall be based on certified test reports, certification of shipment from the supplier and tests performed on samples obtained after delivery in accordance with the Department's Standard Operating Procedures.

The Contractor shall provide suitable means for storing and protecting the GGBFS against dampness and contamination. Separate storage silos, bins or containers shall be provided for GGBFS. GGBFS which has become partially set, caked or contains lumps shall not be used.

The Engineer shall be notified in writing of the nature, amount and identity of any processing or other additions made to the GGBFS during production.

GGBFS from different mills shall not be mixed or used alternately in any one class of construction or structure without written permission from the Engineer; except that this requirement will not be applicable to cement treatment of design soils or bases.

In addition to these requirements, GGBFS shall meet the following specific requirements.

714.06.2--Specific Requirements. GGBFS shall meet the requirements of

AASHTO Designation: M 302, Grade 100 or 120. GGBFS shall contain no chlorides.

714.07--Blank.

714.08--Frames, Grates, Covers, and Ladder Rungs. Metal units shall conform to the plan dimensions and to the applicable requirements in Sections 716 or 717.

Galvanizing, where specified for these units, shall conform to the requirements of AASHTO Designation: M 111, unless otherwise designated.

714.09--Blank.

714.10--Elastomeric Bearings.

714.10.1--General. This work shall consist of furnishing and installing elastomeric bearings in accordance with the plans and these specifications. All required testing and furnishing of sample bearings is considered to be part of the covered work. Shop drawings shall be approved by the Engineer prior to beginning of fabrication or production of bearings.

Elastomeric bearings, as herein defined, shall include plain or nonreinforced pads consisting of elastomer only, and reinforced or laminated bearings consisting of elastomer reinforced with steel laminates.

All elastomeric bearings shall be furnished to the dimensions indicated on the plans. They shall be composed of the specified elastomer type, grade and hardness or shear modulus; shall be adequate for the specified design load; shall be tested at the appropriate level; and shall satisfy any special requirements as shown on the plans.

714.10.2--Elastomer. The raw elastomer shall be virgin polychloroprene (Neoprene), Grade 3 as referenced in ASTM Designation: D 4014.

Elastomer for plain or nonreinforced bearings shall be 70-Durometer, adequate for 800 pounds per square inch design compression stress, and shall be tested to Level I as hereinafter described.

Unless otherwise shown on the plans, elastomer for laminated or reinforced bearings shall be 50-Durometer, adequate for 1,000 pounds per square inch design compression stress, and shall be tested to Level I as hereinafter described.

An elastomer of higher grade number may be substituted for the specified grade.

The elastomer compound shall also meet the minimum requirements of Table I

except as otherwise specified by the Engineer. When test specimens are cut from the finished product, a 10 percent variation in physical properties shall be permitted. All material tests shall be carried out at $73 \pm 4^{\circ}\text{F}$ unless otherwise specified.

TABLE I

Material Property	ASTM Designation	Test Requirements	Polychoroprene			Units
			50 Duro	60 Duro	70 Duro	
Physical Properties	D 2240 D 412	Hardness	50 ±5	60 ±5	70 ±5	Shore A Pts.
		Minimum tensile strength	2250	2250	2250	psi
		Minimum ultimate elongation	400	350	300	%
Heat Resistance at specified temperature	D 573	Specified temperature of the test for 22 hours	212	212	212	°F
		Aging time	70	70	70	Hours
		Maximum change in durometer hardness	+15	+15	+15	Shore A Pts.
		Maximum change in tensile strength	-15	-15	-15	%
		Maximum change in ultimate elongation	-40	-40	-40	%
Compression Set at specified temperature	D 395 Method B	Specified temperature of test degrees	212	212		°F
		Maximum permissible set	35	35	35	%
Ozone Resistance	D 1149	Partial pressure of ozone during test	50	50	50	mPa
		Duration of test	100	100	100	Hours
		Tested at 20% strain 100 ±2°F mounting procedure D518, Procedure A	no cracks	no cracks	no cracks	

(Continued on next page)

TABLE I - (Continued)

Material Property	ASTM Designation	Test Requirements	Polychoroprene			Units
			50 Duro	60 Duro	70 Duro	
Low Temperature	D 2137 Method A	Low temperature Brittleness Test required for Grade 3 and 5 only at -13°F for Grade 3 and -40°F for Grade 5	no failure	no failure	no failure	
	D 1415 or D 2240	Low temperature stiffness required for Grades 2, 3 and 5 only. Conditioned for 22 hours at 14°F for Grade 2, 13°F for Grade 3 and -40°F for Grade 5. Maximum change in hardness	+15	+15	+15	Shore A Pts.
	D 1229	Maximum low temperature compression set required for Grades 2, 3 and 5 only when tested at 25% compression for: 22 hours at 32°F for Grade 2, 7 days at 14°F for Grade 3, 14 days at each of 14°F and -13°F for Grade 5.	65	65	65	%

(d) Variation from a Plane Parallel to the Theoretical Surface as determined by Measurements at the edge of the bearings	
Top	slope relative to the bottom of no more than .005 radians
Sides	1/4"
(e) Position of Exposed Connection Members	1/8"
(f) Edge cover of Embedded Laminates or Connection Members	-0, +1/8"
(g) Size of Holes, Slot or Inserts	±1/8"
(h) Position of Holes, Slots, or Inserts	±1/8"

714.10.6--Acceptance Procedure. The acceptance criteria shall be at two levels. Level I acceptance shall be applied to all elastomeric bearings. Level II acceptance criteria shall be applied as required on the plans or contract documents. Level II criteria shall also be used to resolve differences over the acceptance of bearings to which only Level I tests have been applied.

Level I criteria require that bearing pads be manufactured according to this specification and any additional requirements specified on the plans. The manufacturer shall proof load each steel reinforced bearing with a compressive load of 1500 pounds per square inch. If bulging patterns imply laminate placement which does not satisfy design criteria and manufacturing tolerances or if bulging suggests poor laminate bond, the bearing shall be rejected. If there are three (3) separate surface cracks which are greater than 0.08-inch wide and 0.08-inch deep, the bearing shall be rejected.

A copy of the proof loading results for each lot of steel reinforced bearings shall be furnished the Bridge Engineer prior to shipment of the bearings.

The Department reserves the right to require that proof loading be done in the presence of and witnessed by a representative of the Department. Whether a Department representative was present to witness the proof loading or not, the manufacturer's certification concerning compliance with the requirements of the contract shall attest to acceptable proof loading.

Level I criteria require that the elastomer satisfy the minimum properties of Table I. Level I criteria also include bond test for laminated bearings as referenced in ASTM Designation: D 429, Method B.

Level II certification requires that all Level I conditions be satisfied, except that individual condition may be waived by the Engineer if Level II certification is used as an arbitration of disputes. Additionally, shear modulus and compressive stiffness shall be determined in accordance with ASTM Designation: D 4014. The shear modulus shall fall within the range of values specified in Table II. Compressive stiffness tests shall be performed on the complete bearing. The compressive stiffness shall vary by no more than ± 10 percent from the median value of all bearings.

TABLE II

HARDNESS (SHORE A)	50	60	70
Shear Modulus at 73°F, psi	85 - 100	120 - 155	160 - 200

The Contractor shall furnish to the Engineer three copies of the manufacturer's certified test reports and certification that each lot in a shipment complies with the requirements of the contract.

714.10.7--Marking. Each reinforced bearing shall be marked in indelible ink or flexible paint. The marking shall consist of the order number, lot number, bearing identification number, and elastomer type and grade number. Unless otherwise specified in the contract documents, the marking shall be on a face which is visible after the erection of the bridge.

714.10.8--Sampling. A lot for plain bearings shall be the manufacturer's lot. Each designated thickness of laminated bearings used on a project shall constitute a lot. Unless otherwise specified on the plans or in the contract documents, sampling shall be at the rate of one bearing per lot. The supplier shall produce sufficient extra bearings pads to accommodate this sampling. Bearings pads from within a lot shall be selected at random by a representative of the Department as samples for inspection and testing.

714.11--Portland Cement Mortar, Grout and Concrete Patching Compounds.

714.11.1--General. The ingredients for portland cement mortar and grout shall conform to the following requirements:

Portland Cement	701.02
Masonry Cement	701.03
Water	714.01.2
Fine aggregate unless otherwise designated	703.02 or 703.18.
Calcium chloride	714.02
Hydrated lime	714.03.2
Fly Ash	714.05
Limestone Dust	714.03.5

714.11.2--Grout for Pressure Grouting. Grout for pressure grouting shall consist of a mixture of portland cement, water, calcium chloride, fly ash and/or limestone dust and fine sand in the proportions set forth in Section 412.

Fine sand shall meet the following requirements:

<u>Square Mesh Sieve</u>	<u>Percent Passing by Weight</u>
No. 10	100
No. 60	40 - 90
No. 200	0 - 50
Percent Silt	0 - 25
Percent Clay	0 - 12
Percent Organic Material	0 - 3
Plasticity Index	N.P.

714.11.3--Grout for Posttensioned Members. Grout for posttensioned members shall consist of a mixture of:

- 1 part portland cement, Type 1
- 1/4 part fly ash
- 3/4 part washed sand, all passing No. 16 sieve, not more than five percent retained on No. 30
- Four to six gallons of water per bag of cement

A plasticizing admixture, subject to approval by the Engineer, shall be used in accordance with the manufacturer's recommendations.

The grout shall be mixed in a mechanical mixer and shall be agitated until placed.

Members shall not be moved before the grout has set; ordinarily 24 hours minimum at 80°F or higher.

714.11.4--Blank.

714.11.5--Masonry Mortar. Masonry mortar shall consist of masonry cement mixed in accordance with the formula shown on the bag or shall consist of one part portland cement, three parts mortar sand, and sufficient water to make a mortar of such consistency that it can be easily handled and spread with a trowel. The addition of hydrated lime will be permitted in the proportion of 1/10 part by volume of the cement.

Mortar for use in other than masonry work, fine aggregate meeting the requirements of Subsection 703.02 may be used.

Unless an approved mortar mixing machine is used, the sand and mortar mix, or cement and lime, shall be mixed dry in a tight box until the mixture assumes a

uniform color, after which water shall be added as the mixing continues until the mortar attains the proper consistency.

Mortar shall be used within 45 minutes after its preparation. Retempering of mortar will not be permitted.

714.11.6--Rapid Setting Commercial Grouts and Concrete Patching Compounds. Rapid setting commercial grouts and concrete patching compounds must be approved for listing in the Department's "Approved Sources of Materials" prior to use, and shall be premeasured and packaged dry by the manufacturer. All liquid solutions included by the manufacturer as components of the packaged material shall be packaged in a watertight container. The manufacturer may include aggregates in the packaged material or recommend the addition of Contractor furnished aggregates.

The type, size and quantity of aggregates, if any, to be added at the job site shall be in accordance with the manufacturer's recommendations and shall meet the requirements of Subsection 703.02 for fine aggregate and Subsection 703.03 for coarse aggregate. Required mixing water to be added at the job site shall meet the requirements of Subsection 714.01.2.

Only those bonding agents, if any, recommended by the manufacturer of the grout or patching compounds may be used for increasing the bond to old concrete or mortar surfaces.

Grout or patching compounds containing chlorides will not be permitted when in contact with steel.

Site preparation, proportioning of materials, mixing, placing and curing shall be performed in accordance with the manufacturer's recommendation for the specific type of application, and the Contractor shall furnish a copy of these recommendations to the Engineer.

Rapid setting non-shrink commercial grouts and concrete patching compounds, including components to be added at the job site, shall conform to the following physical requirements:

Compressive strength shall equal or exceed 3000 psi in 24 hours when tested in accordance with Mississippi Test Method MT-4.

Bond strength shall equal or exceed 100 psi in 24 hours when tested in accordance with Mississippi Test Method MT-4.

The material shall not shrink, and the increase in length at 28 days shall not be greater than 0.3% when tested in accordance with Mississippi Test Method MT-4.

The Contractor shall furnish to the Engineer three copies of the manufacturer's certified test report(s) showing results of all required tests and certification that the material meets the specifications when mixed and placed in accordance with the manufacturer's instructions. When the mixture is to be placed in contact with steel, the certification shall further state that the packaged material contains no chlorides. Certified test report(s) and certification shall be furnished for each lot in a shipment.

The proportioning of materials must be approved by the State Materials Engineer and any subsequent change in proportioning must also be approved. A sample of each component shall be submitted to the Engineer along with the quantity or percentage of each to be blended. At least 45 days must be allowed for initial approval.

The proportioning of materials for subsequent lots may be approved by the State Materials Engineer upon receipt of certification from the manufacturer that the new lot of material is the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

714.11.7--Commercial Grout for Anchoring Doweled Tie Bars in Concrete.

714.11.7.1--Epoxy Grout Anchor System. Epoxy grout shall consist of one part liquid epoxy to a maximum of four parts clean dry silica sand by volume. The epoxy shall be a two-component epoxy-resin bonding system for application to portland cement concrete. The silica sand shall be bagged general purpose blast cleaning sand. The grout shall be placed with equipment that dispenses the grout evenly around the bar and completely fills the hole. Tamping the material in the hole by hand will not be satisfactory.

714.11.7.2--Non-Expanding Chemical Anchor System. Chemical anchor system shall consist of a premeasured unit containing polymeric or epoxy type resin, a hardener and may also include quartz sand aggregate. The resin and hardener shall be isolated from each other by a physical-chemical barrier or may be contained in separate premeasured units.

714.11.7.3--Installation. Unless otherwise specified, installation and hole sizes shall be in accordance with the manufacturer's recommendations.

714.11.7.4--Acceptance Procedure. The anchor system must be one from the Department's "Approved Sources of Materials". Prior to use, the Contractor shall furnish the Engineer three copies of the manufacturer's certification for each shipment stating that the material furnished is of the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

Each day an in-place tension test shall be performed at random on a tie bar with a

maximum curing time of two hours. If the test fails to meet the total load required to stress the bar to 50,000 psi, three additional tests shall be made at random. If any of the additional tests fail, all bars installed on that day shall be tested and any bar that fails shall be replaced. The Contractor shall furnish the testing device which shall include a certified calibration chart. No separate measurement for payment will be made for the testing device.

714.11.8--Epoxy Joint Repair System.

714.11.8.1--General. When the epoxy system is from the Department's current list of "Approved Sources of Materials", the Contractor shall furnish the Engineer three copies of the manufacturer's certification, for each shipment, stating that the epoxy and all components is the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

If the materials proposed for use are not from the Department's current list of approved materials, a sample of the epoxy and all components required for the epoxy mortar mix shall be submitted to the Engineer for evaluation and approval at least 30 calendar days prior to placement. Subsequent approval of each shipment may be by manufacturer's certification as set out above.

A representative of the epoxy manufacturer must be present for sufficient time to assure that the Contractor is properly schooled in the use of the epoxy materials.

714.11.8.2--Epoxy Resin. The material shall meet the requirements of ASTM Designation: C 881, Type I, Grade 2, Class C.

714.11.8.3--Silica Sand. The material shall be bagged general purpose blast cleaning sand.

714.11.8.4--Epoxy Mortar Mix. The mortar mix shall consist of one part liquid epoxy to 3.5 parts clean dry sand by volume.

714.11.8.5--Mixing and Curing. Mixing of all epoxy materials shall be accomplished with a mechanical mixer. A trial batch of mortar, approximately one cubic foot, will be mixed and used for joint repair. From this batch, the pot life and subsequent amount of material to be mixed will be determined.

714.12--Sprayed Finish for Concrete Surfaces. The spray material shall be an approved commercial product designed specifically for a sprayed finish and when applied to the concrete specimens at a rate of one gallon per 50 square feet shall conform to the following requirements:

714.12.1--Freeze-Thaw Test. Cast and cure three concrete specimens, not less than 4" x 6" x 6". Fourteen days moist curing with a drying period in room air at

60° to 80°F for 24 hours before coating with spray finish is required. Caution shall be taken that there be no excessive oil on specimen forms. Sides of specimens, brush permitted, shall be coated as herein set out and cured at room temperature for 48 hours; after which:

- (a) Immerse in water at room temperature, 60° to 80°F for three hours; remove and,
- (b) Place in cold storage at -15°F for one hour; remove and,
- (c) Thaw at room temperature, 60° to 80°F, for one hour.
- (d) Repeat (b) and (c) for 50 cycles.

At the end of the 50 cycle Freeze/Thaw Test, the specimens shall show no visible defects.

714.12.2--Accelerated Weathering. Material shall be subjected to a 5000 hour exposure test in accordance with ASTM Designation: G 151. Testing shall be performed in conjunction with either ASTM Designation: G 153, Carbon Arc Light Apparatus, or ASTM Designation: G 155, Xenon Arc Light Apparatus. Test Exposure Conditions shall be as specified in Table X1.1, Cycle 1 in ASTM Designation: G 153, or Table X3.1, Cycle 1 in ASTM Designation: G 155. At the end of the exposure test, the exposed sample must not show any chipping, flaking or peeling.

714.12.3--Fungus Growth Resistance. Material to be used shall pass a fungus resistance test as described by ASTM Designation: D 3273 with a minimum incubation period of 21 days where no growth shall have been indicated after the test.

714.12.4--Color. Unless otherwise specified or directed by the Bridge Engineer, the color of the finish shall be that deemed by the Engineer to be as close as practicable to the color of a rubbed concrete finish.

714.12.5--Testing and Certification. All testing shall be performed by a qualified commercial testing laboratory acceptable to the Engineer.

Before any part of a shipment is applied on the project, the Contractor shall furnish the Engineer with a certificate from the manufacturer attesting that the commercial product furnished conforms to the same formula as that previously subjected to the specified tests, and approved. Copies of the current test reports shall be attached to the certificate.

No test report for tests made more than four years prior to shipment to the project will be accepted.

714.13--Geotextiles.

714.13.1--General. Unless specified otherwise, the geotextile may be woven or non-woven. The fibers used in the manufacture of the geotextiles and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed of at least 95% by weight polyolefins, polyesters, or polyamides. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvages. The geotextile shall be mildew resistant and inert to biological degradation and naturally encountered chemicals, alkalines and acids. Geotextile which is not protected from sunlight after installation shall contain stabilizers and/or inhibitors to make it resistant to deterioration from direct sunlight, ultraviolet rays, and heat.

The edges of the geotextile shall be selvaged or finished in such a manner to prevent the outer yarn of filaments from raveling. The geotextile shall be free of defects or flaws, which affect the required physical properties.

Geotextile for silt fence shall be manufactured in widths of not less than three feet, and geotextile for other applications shall be manufactured in widths of not less than six feet. Sheets of geotextile may be sewn or bonded together at the factory or other approved locations, but deviation from the physical requirements will not be permitted.

Acceptance testing will be conducted with geotextile samples from each lot shipped to the project, as per Subsection 714.13.10.

714.13.2--Geotextile for Silt Fence. The geotextile shall conform to the physical requirements of Type I or II as shown in Table I. Unless a specific type is specified in the plans or contract documents, the Contractor may select Type I or II.

714.13.2.1--Woven Wire Backing. Except as provided herein, silt fence shall be reinforced with a woven wire backing. The wire backing shall be at least 32 inches high and have no less than six horizontal wires. Vertical wires shall be spaced no more than 12 inches apart. The top and bottom wire shall be 10-gauge or larger. All other wire shall be no smaller than 12½-gauge.

714.13.2.2--Posts. Wood or steel posts may be used. Wood posts shall have a minimum diameter of three inches and length of five feet and shall be straight enough to provide a fence without noticeable misalignment. Steel tee posts shall be five feet long, approximately 1 3/8" wide, 1 3/8" deep, and 1/8" thick with a nominal weight of 1.33 pounds per foot prior to fabrication. The posts shall have projections, notches or holes for fastening the wire backing or geotextile to the posts.

714.13.2.3--Staples. Staples shall be made of 9-gauge wire with a minimum length of one inch after bending.

714.13.3--Geotextile for Subsurface Drainage. Unless otherwise specified, the geotextile shall conform to the physical requirements of Type III as shown in Table I.

714.13.3.1--Geotextile for Edge Drains. The geotextile shall conform to the physical requirements of Type V as shown in Table I, except the AOS for the woven geotextile shall have a range of 0.15 mm to 0.43 mm.

714.13.4--Geotextile Underseal. The geotextile shall be non-woven polyester or polypropylene, which is satisfactory for use with asphalt cements. Unless otherwise specified, the geotextile shall conform to the physical requirements of Type IV in Table I.

714.13.5--Geotextile for Use Under Riprap. Unless otherwise specified, the geotextile shall conform to the physical requirements of Type V in Table I. The requirements for grab tensile, puncture, and trapezoidal tear strengths may be reduced 50 percent when the geotextile is cushioned from rock placement by a 6-inch minimum layer of sand.

714.13.6--Geotextile Stabilization. The geotextile shall meet the physical requirements as shown in Table I for the Type specified in the plans or contract documents.

714.13.7--Securing Pins. Steel pins used for anchoring the geotextile shall be three-sixteenth inch (3/16") in diameter, minimum length of 15 inches, pointed at one end and fabricated with a head for retaining a steel washer. A minimum one and one-half inch (1½") washer shall be installed on each pin.

714.13.8--Identification. Each roll of geotextile or container shall be visibly labeled with the name of the manufacturer, type of geotextile or trade name, lot number, and quantity of material.

714.13.9--Shipment and Storage. During shipment and storage, the geotextile shall be protected from direct sunlight, ultraviolet rays, temperatures greater than 140°F, mud, dirt, dust, and debris. The geotextile shall be wrapped and maintained in a heavy-duty protective covering, including ends of roll.

714.13.10--Certification, Acceptance Sampling and Testing. The Contractor shall furnish to the Engineer three copies of the manufacturer's certification that each lot in a shipment complies with the requirements of the contract. Certification of geotextile for silt fence shall include a material conformance statement, as per Subsection 700.05.1, that the geotextile meets or exceeds the minimum average roll values specified in Table 1. All geotextile, steel pins,

washers, fence posts, woven wire and wire staples are subject to approval by the Engineer upon delivery to the work site.

Acceptance testing shall be completed prior to incorporating in the work.

Acceptance of geotextile to be used in the work will be based on the results of tests performed by the Department on verification samples submitted from the project. The Engineer will select one roll at random, from each lot in a shipment, for sampling. A sample extending full width of the randomly selected roll and containing at least five square yards of geotextile will be obtained and submitted by the Engineer. The sample shall be provided at no additional cost to the State.

714.13.11--Table.

**TABLE I
GEOTEXTILES**

Type Designation	I ^a	II ^a	III	IV	V	VI		VII		
Application	Sediment Control		Drainage	Paving	Separation & Drainage	Separation, Stabilization & Reinforcement				
Physical Properties										Test Method
Grab Strength, Pounds	50	90	110	90	200	W 280	NW 180	W 450	NW 280	ASTM D 4632
Elongation %	----	50% max @ 45 lbs.	20% min	50% min @ break	50% min	50% max	50% min	50% max	50% min	ASTM D 4632
Seam Strength, Pounds	----	----	70	----	180	240	160	400	240	ASTM D 4632
Puncture Strength, Pounds	----	----	40	----	80	110	75	180	115	ASTM D 4883
Trapezoidal Tear, Pounds	----	----	40	----	80	100	70	150	100	ASTM D 4533
Asphalt Retention, gallons / square yard	----	----	----	0.2	----	----	----	----	----	ASTM D 6140
Permittivity, sec ⁻¹	0.05	0.05	0.5	----	0.15	0.2	0.2	0.2	0.2	ASTM D 4491
AOS Woven, mm	0.15 - 0.84	0.15 - 0.84	0.15 - 0.43	----	0.21 - 0.43	0.15 - 0.21	----	0.15 - 0.21	----	ASTM D 4751
AOS Non-Woven, mm	<0.84	<0.84	<0.43	----	<0.43	----	<0.43	----	<0.43	ASTM D 4751
Tensile Strength after UV, % Retained,	70@500Hr.	70@ 500 Hr.	70@ 150 Hr.	----	70@ 150 Hr.	70@ 150 Hr.		70@ 150 Hr.		ASTM D 4355
Melting Point, °F	----	----	----	325	----	----		----		ASTM D 276

a. All property values, with the exception of apparent opening size (AOS), represent minimum average roll values in the weakest principal direction. Values for AOS represent the maximum average roll values.

714.14--Geotextile for Moisture Barrier.

714.14.1--General. The geotextile for moisture barrier shall consist of sheeting, coated geotextile or a geotextile-sheeting laminate constructed exclusively of man-made materials. Sheeting shall be of single-layered construction. Coated geotextile shall be made of woven or non-woven polyester, polyetholene or polypropylene. The geotextile shall be furnished precoated on one or both sides or impregnated so as to make the geotextile impermeable to water or moisture. Geotextile-sheeting laminate shall consist of geotextile fused or heat-sealed to sheeting so as to form an integral geotextile membrane.

The geotextile shall be able to withstand normal handling and placement at material temperatures from 20°F to 145°F without endangering the serviceability of the material in the intended application. If the geotextile evidences de-lamination, such de-lamination may serve as grounds for rejection. The geotextile shall be mildew, abrasion, and puncture resistant and suitable for long term burial in the presence of water and/or moisture in the intended construction application. It shall be packaged in rolls of the length and width specified on the plans or directed by the Engineer.

714.14.2--Physical Requirements. The geotextile shall meet the following additional requirements when sampled and tested in accordance with the methods specified.

<u>Test</u>	<u>Requirements</u>	<u>Method</u>
Original Physical Properties		
Geotextile weight, ounces per square yard, air-dried tension-free sample.	Texas Test Method Tex-616-J"Testing Construction Fabrics"	6.5 minimum
Water permeability expressed as weight of water in ounces per square yard. Geotextile is subjected to the equivalent of a ten foot column of water for a period of two hours. Moisture passing through the geotextile is determined by weight gain of desiccant.	Tex-616-J	0.6 maximum
Abrasion Resistance expressed as weight of water in ounces per square yard. After prescribed sandblast the geotextile shall meet the requirement for water	Texas Test Method Tex-851-B "METHOD FOR EVALUATING THE ABRASION RESISTANCE OF PAVEMENT MARKING MATERIALS"	0.6 maximum

permeability.	modified as follows: six-inch sample distance, 40 psig regulated blast pressure and one kilogram of blast medium with a blast time of two minutes plus or minus 15 seconds per one kilogram of blast medium.	
Load characteristics at break or 100% elongation, whichever occurs first. Material shall meet specified minimum in both machine direction and cross-machine direction. Test values to be expressed in pounds.	ASTM Designation: D 5034, Grab Test G with 1-inch x2-inch jaws and constant time to break rate of extension of 20 plus or minus three seconds, as specified.	150 minimum
Apparent elongation at break or rupture, expressed in percent.	See Grab Test G above	20% minimum
Tear strength determined by the tongue, single rip, method on specimens prepared from "as-received" samples. Specimens are to be tested at a cross-head speed of twelve plus or minus 0.5 inches/minute. Test results are to be calculated by the "average of five highest peaks" method. Both the average of five specimens cut with the longer dimension parallel to the machine direction and the average of five specimens cut in the cross-machine direction shall meet the specified minimum expressed in pounds.	ASTM D 751	15 minimum

714.14.3--Packaging Requirements. The geotextile shall be packaged in rolls of the length and width specified on the plans or directed by the Engineer. The material shall be uniformly wound onto suitable cylindrical forms or cores to aid in handling and unrolling. Each roll shall be packaged individually in a suitable

sheath, wrapper or container to protect from ultraviolet light and moisture damage during normal storage and handling.

714.14.4--Identification. Each roll of geotextile or container shall be visibly labeled with the name of the manufacturer, type of geomembrane or trade name, date, lot number and length, width and quantity of material.

714.14.5--Sampling. A sample of five square yards of the geotextile shall be furnished to the State from each shipment for verification testing. The samples shall be provided at no cost to the State.

714.14.6--Certification. The Contractor shall furnish to the Engineer three copies of the manufacturer's certified test report(s) showing results of all required tests and certification that the material meets the specifications. Certification shall be furnished for each lot in a shipment.

714.15--Geogrids.

714.15.1--General. A geogrid is defined as a geosynthetic formed by a regular network of integrally connected elements with apertures greater than 0.25 inch to allow interlocking with surrounding soil, rock, earth and other surrounding materials to function primarily as reinforcement.

The geogrid shall be creep tested in accordance with ASTM Designation: D 5262. The long term design load that shall be reported for design use, shall be that load at which no more than 10% strain occurs over a 100-year design life of the geogrid, as calculated from tests run on representative samples for no less than 10,000 hours. The long term design load shall be reported unfactored, as the AASHTO strength reduction - Durability and Installation, and safety factors - will be considered by the MDOT Geotechnical Branch on a site specific design basis.

The geogrid shall meet the physical requirements of Table II for the type shown on the plans and shall be selected from the Department's list of "Approved Sources of Materials."

The geogrid shall be mildew resistant and inert to biological degradation and naturally encountered chemicals, alkalis and acids. The geogrid shall contain stabilizers and/or inhibitors, or a resistance finish or covering to make it resistant to deterioration from direct sunlight, ultraviolet rays, and heat.

714.15.2--Marking, Shipment and Storage. Each roll or container of geogrid shall be visibly labeled with the name of the manufacturer, trade name of the product, lot number, and quantity of material. In addition, each roll or container shall be clearly tagged to show the type designation that corresponds to that required by the plans. During shipment and storage the geogrid shall be

protected from direct sunlight, and temperatures above 120°F or below 0°F. The geogrid shall either be wrapped and maintained in a heavy duty protective covering or stored in a safe enclosed area to protect from damage during prolonged storage.

714.15.3--Manufacturer’s Certification. The Contractor shall furnish the Engineer three copies of the manufacturer’s certified test reports indicating that the geogrid furnished conforms to the requirements of the specifications and is of the same composition as that originally approved by the Department.

714.15.4--Acceptance Sampling and Testing. Final acceptance of each shipment will be based upon results of tests performed by the Department on verification samples submitted from the project, as compared to the manufacturer’s certified test reports. The Engineer will select one roll or container at random from each shipment for sampling. A sample extending full width of the randomly selected roll or container and being at least five (5) square yards in area will be obtained and submitted by the Engineer. The sample from each shipment shall be provided at no cost to the State.

**TABLE II
GEOGRIDS**

MINIMUM AVERAGE ROLL VALUE

Physical Properties	Type Designation						Test Method
	I	II	III	IV	V	VI	
Long Term Design Load, pounds per foot, Machine Direction	250	500	750	1500	2500	3500	ASTM Designation: D-5262
Minimum Ultimate Tensile Strength, pounds per foot, Machine Direction	500	1000	1500	3000	5000	7000	ASTM Designation: D-4595
Open Area, percent	70	70	50	50	50	50	Direct Measurement

SECTION 715 - ROADSIDE DEVELOPMENT MATERIALS**715.01--Topsoil.**

715.01.1--General. Topsoil shall be a well-graded soil of good uniform workable quality, free of debris, refuse, or foreign material and reasonably free of hard clods, gravel, concrete, sticks, or other undesirable material harmful to plant life.

715.01.2--Material to be Obtained from the Right-of-Way. Topsoil for slope treatment shall meet the general requirements as stated above and shall have a pH value of not less than 4.5 nor more than 8.0.

715.01.3--Material to be Furnished by the Contractor. Topsoil for slope treatment shall meet the general requirements of Subsection 715.01.1, shall have a pH value of not less than 4.5 nor more than 8.0, and shall be classified as a Group A-4 or A-6 soil with a minimum PI of 6.0 as specified by AASHTO Designation: M 145.

Topsoil for plant holes or pits shall be a rich, well-graded, well-drained soil of good uniform quality. The organic content, unless otherwise specified, shall not be less than three percent nor more than 20% as determined by ignition test on oven-dried samples. The pH value of the topsoil shall not be less than 4.5 nor more than 8.0. The Contractor may elect to mix or blend the materials for plant holes or pits so as to insure a homogenous mixture complying with the specific requirements of these specifications. No extra compensation will be allowed for the blending or mixing of materials.

715.01.4--Sampling and Testing. Sampling and testing of topsoil shall be as set out in Subsection 700.03.

715.02--Fertilizers.

715.02.1--General. Fertilizers shall comply with the fertilizer laws of the State of Mississippi.

715.02.2--Commercial, Combination or Manufactured, Fertilizer. Combination or manufactured fertilizer shall be "standard commercial products" and shall contain not less than the percentages by weight of the ingredients set out in Table A, except for agricultural limestone which shall meet the requirements of Subsection 715.02.2.1.

TABLE A
TYPES OF FERTILIZERS

	Combination												
	*10	18	6	15	12	8	0	13	Super Phosphate	Ammonium Nitrate	Urea	Muriate Potash	Ureaform
	10	46	8	10	24	24	20	13					
	10	0	8	10	12	24	20	13					
Chemical Components													
Nitrogen	*10	18	6	15	12	8	0	13		33	45		*38
Phosphorous P ₂ O ₅	10	46	8	10	24	24	20	13	20				
Potash K ₂ O	10	0	8	10	12	24	20	13				60	

- * Ureaform (38-0-0) -- This fertilizer shall contain a minimum of 38% total nitrogen, 27% of which shall be insoluble nitrogen derived from ureaform. The final mixture shall have a minimum activity index (AI) of 50% as determined by the appropriate AOAC procedure.
- * Ureaform (10-10-10) -- This fertilizer shall contain a minimum of 10% total nitrogen, 35% of which shall be insoluble nitrogen derived from ureaform. The final mixture shall have a minimum activity index (AI) of 40% as determined by appropriate AOAC procedure.

715-02.2.1--Agricultural Limestone. Agricultural limestone shall be either a Grade “A” liming material, or a marl or chalk agricultural liming material as addressed in the latest Mississippi Agricultural Liming Material Act of 1993, published by the Mississippi Department of Agriculture and Commerce.

715-02.2.1.1--Screening Requirements. Grade “A” liming material, including ground shells, shall not have less than 90% of the material passing the No. 10 sieve, and not less than 50% passing the No. 60 sieve. Marl or chalk liming material shall not have less than 90% of the material passing the No. 10 sieve.

715-02.2.1.2--Neutralizing Values. Grade “A” liming material shall not have less than 90% calcium and magnesium carbonate calculated as calcium carbonate equivalent when expressed on a dry weigh basis. Marl or chalk liming material shall not have less than 70% calcium and magnesium carbonate calculated as calcium carbonate equivalent when expressed on a dry weigh basis.

715.02.3--Sampling and Testing. Sampling and testing of agricultural limestone shall be in accordance with Subsection 700.03. Labels on containers or attached thereto showing the guaranteed analysis of other fertilizers will be prima facie evidence as to conformity with the specified requirements.

715.03--Seed.

715.03.1--General. All seeds shall comply with the seed law of the State of Mississippi and the current regulations duly promulgated thereunder. The seed shall be delivered in bags with certified tags or labels attached to each bag showing the seed name, kind, variety, percent of germination and purity of the seed, and the percent of obnoxious weeds and inert matter.

715.03.2--Germination and Purity Requirements. The requirements for germination and purity shall be as set out in Table B:

TABLE B
Germination and Purity Requirements

Name (Kind)	Name (Variety)	Percent Germination	Percent Purity
GRASSES			
Bermudagrass	Common	85	95
Bahiagrass	Pensacola or Wilmington	85	85
Tall Fescue	Kentucky 31	80	95
Lovegrass	Weeping	80	97
Carpetgrass	-----	80	85
Millet	Browntop	85	98
Oats	-----	90	98
Rye Grain	-----	80	98
Centipede	-----	80	85
LEGUMES			
Crimson Clover	Dixie, Chief, Tibbee, or Autauga	85	98
Annual Lespedeza	Kobe, Summit, or Climax	80	98
Sericea Lespedeza	Common, Interstate or Serala	80	98
Lespedeza	Vergata	90	98
Vetch	Hairy	85	95

715.03.3--Sampling and Testing. Except as provided in Subsection 214.02, the certified analysis shown on the seed bags will be used to determine the purity, obnoxious seeds, and inert matter as to conformance with the above requirements. Seeds from bags not identified by certified analysis or from bags with certified analysis indicating the seeds do not meet contract requirements shall not be used.

All seeds will be sampled and tested for percent germination, and the Department reserves the right to sample and test seeds for any required characteristic when deemed appropriate to do so as a check on the quality of the seeds; in which case the results of such tests shall be the basis for acceptance, rejection, or adjustment under the provisions of the contract.

Seeds to be tested by the Department will be sampled under the supervision of the District Materials Engineer. The seeds sampled by Department personnel will be sampled by means of a probe through the seed bags that are stored in accordance with Subsection 214.02.

The procedures for sampling, testing, acceptance, rejection, or adjustment will be in accordance with Subsection 214.02 supplemented by Department SOP.

715.03.4--Leguminous Inoculants. Approved legume seeds shall be treated with leguminous inoculant under the supervision of the Engineer. The inoculants for treating leguminous seeds shall be standard, pure culture of nitrogen fixing

bacteria. The seed shall be treated at the rate specified and according to the directions shown on the container of the inoculants and before the expiration date for use of the inoculant as also shown on the container.

715.04--Water. Water used in planting and establishment of vegetation shall comply with the applicable requirements of Subsection 714.01.

715.05--Vegetative Materials for Mulch. The vegetative materials for mulch shall be classed as follows:

Type I - Approved baled straw of wheat, oat, rye grain, or rice or broomsage or Bahia grass with seed heads which has reached maturity prior to cutting.

Type II - Approved baled hay produced from Bermuda, Bahia, Fescue, Dallis Grass, any of the Lespedezas, or combinations thereof.

All of the above materials shall have been properly cured prior to baling and shall be reasonably free from Johnson Grass and other noxious grasses and weeds. Vegetative material shall be reasonably bright in color, dry, and shall not be musty, moldy, or of otherwise low quality. Vegetative material that is wet or that has been baled green, not cured properly, shall not be used.

Unless otherwise permitted in writing by the Engineer, Type I shall be furnished and used. The Engineer may permit the use of Type II when the Contractor has furnished satisfactory evidence in writing that Type I material is not available.

715.06--Blank.

715.07--Mulch for Woody Plant Materials. The mulch materials shall conform to the following.

715.07.1--Tree Bark Mulch. The mulch shall be a standard manufactured product of ground, shredded, or broken particles from the bark of trees and shall be reasonably free of weed seeds, harmful bacteria, or disease spores and substances toxic to plant growth. The mulch particles shall be of the following type(s), as specified in the contract:

Type I - Commonly known as extra coarse. Particle size shall be approximately one inch to 2 1/2".

Type II - Commonly known as coarse. Particle size shall be approximately 1/2 inch to one inch.

Type III - Commonly known as medium. Particle size shall be approximately 1/4 inch to 1/2 inch.

Type IV - Commonly known as fine. Particle size shall be approximately 1/8 inch to 1/4 inch.

All tree bark mulch shall be handled so as to insure proper protection against contamination at all times. The mulch shall be delivered to the job in unbroken bags or bales with a manufacturer's label or tag on each container. Labels or tags on the containers shall show the physical analysis of the contents, the size of the particles, and the volume. Labels on containers or attached thereto showing the guaranteed analysis and volume will be prima facie evidence of the materials meeting the above requirements. All mulch will, however, be subject to approval by the Engineer as to quality and quantity.

715.07.2--Aggregate Mulch. Aggregate used as mulch shall be crushed or uncrushed gravel Size 5 or Size 56 meeting the gradation requirements of Subsection 703.14 for coarse aggregate cover material.

715.07.3--Straw. Straw material for mulch shall be classed as follows:

Class I - Approved baled wheat, oat, rice or rye straw. The materials shall have been cured properly prior to baling and shall be reasonably free from obnoxious grasses and weeds. The straw material shall be reasonably bright in color, dry and shall not be musty, moldy, or of otherwise low quality.

Class II - Approved baled pine needles that is reasonably free of twigs, branches, and obnoxious grasses and weeds. The material shall be dry and shall not be musty, moldy, or of otherwise low quality.

All straw mulch shall be inspected and approved by the Engineer prior to its use.

715.08--Fertilizer for Woody Plant Material. The fertilizer material for woody plants shall conform to the following requirements:

715.08.1--Fertilizer Packet. The fertilizer packet shall consist of an approved manufactured sealed polyethylene-paper laminated perforated packet containing one, two, or four ounces of water soluble fertilizer with a minimum guaranteed analysis of 16-8-16, 16% Nitrogen, 8% Phosphoric Acid, 16% Potash.

715.08.2--Fertilizer Tablet. The fertilizer tablet shall consist of an approved tightly compressed slow-release tablet 5, 10 or 21 gram size containing a minimum guaranteed analysis of 20-10-5, 20% Nitrogen, 10% Phosphoric Acid, 5% Potash.

715.08.3--Guaranteed Analysis. Labels on containers or attached thereto showing the guaranteed analysis will be prima facie evidence of the fertilizer materials meeting the specified requirements. All fertilizer packets and tablets will, however, be inspected and approved by the Engineer or, at the Engineer's

discretion, may be sampled and tested.

715.09 - Ditch Liner Material. All ditch liner materials shall be new and free of rips or tears.

715.09.1--Jute Mesh. Jute mesh shall be of uniform, plain weave with warp and weft yarns of approximately the same size. The physical requirements shall be:

Length	50 yards per roll, minimum
Width	48 inches, plus or minus one inch
Warp ends	78 per width, minimum
Weft yarns	41 per yard, minimum

The weight of cloth shall average 1.22 pounds per linear yard with a tolerance of plus 10% or minus 5%.

715.09.2--Excelsior Blanket. The excelsior blanket shall consist of a machine-produced mat of interlocking wood excelsior with uniform thickness and the fiber evenly distributed over the entire area of the blanket. A fabric net of extruded plastic shall be applied to one side of the excelsior wood mat to hold the wood fibers in place.

The blankets shall be supplied in a protective covering and shall not be exposed to moisture prior to placing. The blankets shall meet the following physical requirements.

Interlocking Wood Fibers	0.020" x 0.04" (±25%), 50% must be 3½ inches or longer
Fabric Net	1½" x 3½" maximum mesh size
Width	36-inch minimum

715.09.3--Erosion Control Blanket. The erosion control blanket shall consist of a machine-produced mat whose primary component is clean, weed-free straw from cereal grain crops. The straw must be evenly distributed throughout the mat. The top side of the blanket shall be covered with a photodegradable plastic mesh having 3/4" x 3/4" maximum openings which shall be substantially adhered to the straw by a knitting process using degradable thread. The blanket shall be supplied in a protective covering and shall meet the following requirements:

Straw *	0.50 pounds per square yards minimum dry weight
Netting	Photodegradable plastic
Width	48-inch minimum

* Coconut fiber may be used to replace a portion or all of the straw.

715.09.4--Erosion Control Fabric. The erosion control fabric shall consist of a flexible knitted construction of high strength degradable yarn with uniform openings interwoven with strips of biodegradable paper and shall conform to the following requirements:

- Width 48-inch minimum
- Weight 0.2 pounds per square yard, approximate

715.09.5--Wire Staples. The staples for securing the ditch liner material in place shall be a double prong "U" configuration made from 11-guage or heavier steel wire with an approximate length of six inches after bending.

715.09.6--Roving.

715.09.6.1--Polypropylene Roving. This material shall be formed from continuous strands of fibrillated polypropylene yarn, collected into a rove. Fibrillation is defined as a net-like physical structure of the yarn created by splitting the yarn in a precise pattern during manufacture.

The polypropylene shall contain a sufficient amount of UV inhibitors so as to retain 70 percent of its strength after 500 hours of exposure in an Atlas Twin Arc Weatherometer.

The fibrillated polypropylene roving shall have the following detailed requirements:

<u>Property</u>	<u>Limits</u>	<u>Test Method</u>
Strands / Rove	20-30	End Count
Yards per Pound of Rove	410-620	ASTM Designation: D 1907
Package Weight, pounds	18 minimum	Scale
Color	Black	

715.09.6.2--Fiberglass Roving. The material shall be formed from continuous fibers drawn from molten glass, coated with a chrome complex sizing compound, collected into strands, and lightly bound together into a rove.

The fiberglass roving material shall meet the following detailed requirements:

<u>Property</u>	<u>Limits</u>	<u>Test Method</u>
Yield, yards per pound	170 - 300	ASTM Designation: D 578
Fiber Diameter, inch	0.00035 - 0.00055	ASTM Designation: D 578
Strands / Rove	50 - 70	End Count
Package Weight, pounds	25-50	Scale

715.09.7--Certification. The Contractor shall furnish the Engineer with three copies of the manufacturer's certification for each shipment of ditch liner material stating the amount furnished and that the material complies with the requirements of the specifications and also forward three copies of the manufacturer's or distributor's certification showing the wire size for each shipment of staples.

The certifications by the manufacturer or distributor will be prima-facie evidence of the materials meeting the specified requirements. All ditch liner material and staples will, however, be subject to approval by the Engineer.

SECTION 716 - MISCELLANEOUS METALS

716.01--General. All miscellaneous metals shall be as shown on the plans or in the special provisions, and shall conform to the requirements as hereinafter set out, unless otherwise specified.

Unless waived by the Engineer, the Contractor shall furnish the State Materials Engineer three copies of certified test reports from an approved testing laboratory covering all material described in this section.

716.02--Steel Castings.

716.02.1--Carbon Steel Castings. Carbon steel castings shall conform to AASHTO Designation: M 103. Grade 70-36 shall be furnished unless otherwise specified.

716.02.2--Chromium Alloy-Steel Castings. Chromium alloy-steel castings shall conform to ASTM Designation: A 743. Grade CA-15 shall be furnished unless otherwise specified.

716.03--Steel Forgings. Steel forgings shall conform to AASHTO Designation: M 102. Class C forgings shall be furnished unless otherwise specified.

716.04--Gray Iron Castings. Gray iron castings shall conform to AASHTO Designation: M 105. Class 30B shall be furnished unless otherwise specified. For testing purposes a lot size shall be defined as the lesser of either a total of 35,000 pounds or one week's production for the Department. The test bar shall be made from a melt of iron used in production of units for the Department. The

test bar length shall be a minimum of 16 inches.

716.05--Malleable Castings. Malleable castings shall conform to ASTM Designation: A 47. Grade No. 35018 shall be furnished unless otherwise specified.

716.06--Bronze Castings and Bearings. Bronze castings and bearings shall conform to AASHTO Designation: M 107. Alloy UNS No. C91100 shall be furnished unless otherwise shown on the plans.

716.07--Copper Bearings and Sheet Copper.

716.07.1--Rolled Copper-Alloy Bearings and Expansion Plates. Rolled copper-alloy bearings and expansion plates shall conform to ASTM Designation: B 100. Alloy UNS No. C51000 shall be furnished unless otherwise specified.

716.07.2--Sheet Copper. Sheet copper shall meet the requirements of AASHTO Designation: M 138 including the embrittlement test. The Copper No. shall be as designated on the plans.

716.08--Self-Lubricating Bearing Plates. Self-lubricating bearing plates shall be an article of standard production by an established manufacturer of such equipment. They shall be provided with trepanned or drilled recesses, not grooves, which shall be filled with a lubricating compound capable of withstanding the atmospheric elements and consisting of graphite and metallic substances with a lubricating binder. This compound shall be pressed into the recesses by hydraulic presses so as to form dense nonplastic lubricating inserts. The lubricating area shall comprise not less than 25% nor more than 35% of the total bearing area. Contractor shall furnish additional lubricating material in stick form. Just prior to erecting the members which rest on the bronze plates, the Contractor shall thoroughly rub the steel bearing plates which rest on the bronze with the lubricant. These surfaces shall be unpainted and shall be cleaned with a steel brush immediately before the lubricant is applied.

The bearing plates shall be made of (1) rolled bronze conforming to the requirements of Subsection 716.07.1, or (2) cast bronze conforming to requirements of Subsection 716.06, Alloy UNS No. C91100 or No. C90500, except that a maximum lead content of 2.5% is allowable.

The coefficient of friction shall not exceed 0.10 when subjected to design loading and also when subjected to twice the design loading.

Contact surfaces shall be finished in the direction of motion in accordance with the requirements of ANSI B46 1-55 No. 125. All machined surfaces shall be flat within 0.0005 inch per inch of length and width. In mating curved surfaces of steel and bronze, the concave surfaces may have a plus tolerance of 0.01 inch and

the convex surfaces, a minus tolerance of 0.01 inch.

The Contractor shall furnish the manufacturer's shop drawings showing pattern and size of recesses.

716.09--Babbitt. Babbitt shall conform to ASTM Designation: B 23. The alloy number shall be as designated on the plans.

716.10--Lead Plates, Pipes, Etc. Lead used for plates, pipes, etc. shall conform to ASTM Designation: B 29, Grade: Pure Lead.

716.11--Galvanized Pipe. Galvanized pipe for water, gas, etc. shall conform to ASTM Designation: A 53.

716.12--Rolled Zinc. Rolled zinc shall conform to ASTM Designation: B 69. The type shall be as designated on the plans.

716.13--Blank.

716.14--Bar Grates.

716.14.1--Material Requirements. Plain round steel bars and strap bars shall conform to the following requirements:

B-9 Grates and Bar Grates	AASHTO Designation: M 270, Grade 36
MI, GI, & SS-3 Grates	AASHTO Designation: M270, Grade 50W, or ASTM Designation: A 588, Grade 50W

716.14.2--Fabrication and Finish. All bar grates shall be constructed in accordance with these specifications and in conformity with the detailed plans.

Holes shall be punched or drilled in the strap bars to accommodate the round bars. The junctions of all round bars and/or strap bars shall be welded. The completed bar grate shall exhibit good workmanship.

After fabrication, the bar grate shall be coated with an approved commercial quality coating designed for coating steel castings and fabricated units. The State Materials Engineer shall approve the coating material prior to application.

SECTION 717 - STRUCTURAL STEEL

717.01--Structural Steel.

717.01.1--General. Steel shall be furnished according to the following

specifications. Unless otherwise specified, structural carbon steel shall be furnished. Steels other than those required herein may be specified on the plans. When steel is used in welded construction, the welding procedure shall be suitable for the steel and the intended service.

717.01.2--Requirements for Structural Steel. Structural steel shall meet the applicable ASTM Standards which shall include the Supplementary Bend Test Requirement and the following Charpy V-Notch Requirements for minimum service temperature 0°F and above:

ASTM DESIGNATION	THICKNESS & FABRICATION	MINIMUM CHARPY V-NOTCH ENERGY @ TEMPERATURE
A 36	Up to 4"	15 ft. lb. @ 70°F
*A 588	Up to 4" Mechanically Fastened	15 ft. lb. @ 70°F
*A 588	Up to 2" Welded	15 ft. lb. @ 70°F
*A 588	Over 2" to 4" Welded	20 ft. lb. @ 70°F
*A 572	Up to 4" Mechanically Fastened	15 ft. lb. @ 70°F
*A 572	Up to 2" Welded	15 ft. lb. @ 70°F
*A 572	Over 2" to 4" Welded	20 ft. lb. @ 70°F
A 514	Up to 4" Mechanically Fastened	25 ft. lb. @ 30°F
A 514	Up to 2½" Welded	25 ft. lb. @ 30°F
A 514	Over 2½" to 4" Welded	35 ft. lb. @ 30°F
A 852	Up to 4" Mechanically Fastened	20 ft. lb. @ 50°F
A 852	Up to 2½" Welded	20 ft. lb. @ 50°F
A 852	Over 2½" to 4" Welded	25 ft. lb. @ 50°F

* If the yield strength of the material exceeds 65 ksi, the temperature for the CVN value for acceptability will be reduced 15°F for each increment or fraction thereof of 10 ksi above 65 ksi.

The procedure for sampling and testing shall be in accordance with ASTM Designation: A 673. The (H) Frequency of Heat Testing shall be used for all the steel specifications except ASTM Designation: A 514 which shall be in accordance with the (P) Frequency of Piece Testing.

If ASTM Designation: A 517 steel is used in lieu of A 514, the sampling and testing requirements shall be the same as the A 514 of equal thickness.

717.01.3--Structural Carbon Steel. Structural carbon steel for bolted and welded construction shall be in accordance with ASTM Designation: A 36.

717.01.4--Eyebars. Steel for eyebars shall be a weldable grade. These grades include structural steel conforming to:

- (a) Structural Carbon Steel ASTM Designation: A 36.

- (b) High-Strength Low-Alloy Structural Steel with 50,000 psi, minimum yield point to four inches (4") thick, ASTM Designation: A 588 with supplementary requirements for Charpy V-Notch mandatory.

717.01.5--High Strength Low-Alloy Structural Steel. High-Strength Low-Alloy Structural Steel shall conform to:

- (a) High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality, ASTM Designation: A 572.
- (b) High-Strength Low-Alloy Structural Steel with 50,000 psi, minimum yield point to four inches (4") thick, ASTM Designation: A 588.

717.01.6--High Strength Low-Alloy Structural Steel for Welding. High-Strength Low-Alloy Structural Steel for welding shall conform to:

- (a) High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality, ASTM Designation: A 572, Grade 50.
- (b) High-Strength Low-Alloy Structural Steel with 50,000 psi, minimum yield point to four inches (4") thick, ASTM Designation: A 588.

717.01.7--High-Strength Structural Steel for Bolted Construction. High-Strength Structural Steel for bolted construction shall conform to:

- (a) High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality, ASTM Designation: A 572, Grade 50.
- (b) High-Strength Low-Alloy Structural Steel with 50,000 psi, minimum yield point to four inches (4") thick, ASTM Designation: A 588.

717.01.8--High-Yield-Strength, Quenched, and Tempered Alloy Steel Plate. High-Yield-Strength, Quenched and Tempered Alloy Steel Plate shall conform to:

- (a) High-Yield-Strength, Quenched, and Tempered Alloy Steel Plate, suitable for welding, ASTM Designation: A 514.
- (b) High-Strength Alloy Steel Plates, Quenched and Tempered for pressure vessels, ASTM Designation: A 517.

717.01.9--Acceptance Procedure. Structural Steel shall be accepted on the basis of manufacturer's certified test reports. The Contractor shall furnish the Engineer with three copies of the certified test reports.

717.02--Fasteners. Fasteners for structural steel joints shall conform to the ASTM specifications with revisions, as specified herein.

717.02.1-- Plain Finish Fasteners.

717.02.1.1--Bolts. Ungalvanized bolts shall meet the requirements of ASTM Designation: A 325 or ASTM Designation: A 490, as specified on the plans.

717.02.1.2--Heavy Hex Nuts. Ungalvanized nuts shall meet the requirements of ASTM Designation: A 194, Grade 2H, or A 563, Grade DH, as specified on the plans.

717.02.1.3--Hardened Washers. Ungalvanized washers shall meet the requirements of ASTM Designation: F 436.

717.02.2--Galvanized Fasteners.

717.02.2.1--Galvanized Bolts. Bolts shall meet the requirements of ASTM Designation: A 325, Type 1. Galvanizing shall be in accordance with ASTM Designation: A 153, Class C, or ASTM Designation : B 695, Class 50. Thickness of zinc coating shall be measured on the wrench flats or top of bolt head.

717.02.2.2--Galvanized Nuts. Nuts shall meet the requirements of ASTM Designation: A 563, Grade DH. Galvanizing shall be in accordance with ASTM Designation: A 153, Class C, or ASTM Designation: B 695, Class 50. Thickness of zinc coating shall be measured on the wrench flats.

717.02.2.3--Galvanized Washers. Washers shall meet the requirements of ASTM Designation: F 436. Galvanizing shall be in accordance with ASTM Designation: A 153, Class C, or ASTM Designation: B 695, Class 50.

717.02.2.4--Direct Tension Indicators. Direct tension indicators shall meet the requirements of ASTM Designation: F 959 and galvanized in accordance with ASTM Designation: B 695, Class 50.

717.02.3--Revisions to ASTM Specifications.

717.02.3.1--ASTM Designation: A 325. Hardness for bolt diameters 1/2-inch to 1-inch inclusive shall have a minimum Rockwell C Hardness Number of 24 and a maximum Rockwell C Hardness Number of 33.

717.02.3.2--ASTM Designation: A 563. Nuts that are to be galvanized shall be tapped oversize the minimum amount required for proper assembly. The amount of overlap in the nut shall be such that the nut will assemble freely on the bolt in the coated condition and shall meet the rotational-capacity test set out in Subsection 717.02.3.4.

The overlapping requirements of ASTM Designation: A 563, Subsection 7.4, shall be considered maximum values instead of minimum, as currently shown.

Galvanized nuts shall be lubricated with a lubricant containing a dye of any color that contrasts with the color of the galvanizing.

717.02.3.3--ASTM Designation: F 606.

717.02.3.3.1--Bolts. Proof load tests shall be performed in accordance with Method 1, Length Measurement. Minimum frequency of tests shall be as specified in ASTM Designation: A 325 for "Production Lot Method."

Wedge tests on full size bolts are required. If bolts are to be galvanized, the tests shall be performed after galvanizing. Minimum frequency of tests shall be as specified in ASTM Designation: A 325, "Production Lot Method."

717.02.3.3.2--Nuts. Proof load tests shall be performed in accordance with ASTM: F 606, Subsection 4.2. If nuts are to be galvanized, tests shall be performed after galvanizing, overtapping and lubricating.

717.02.3.3.3--Washers. If galvanized washers are supplied, hardness testing shall be performed after galvanizing. The coating shall be removed prior to taking hardness measurements.

717.02.3.4--Rotational-Capacity Testing of Assemblies. Rotational-capacity tests are required and shall be performed on all black or galvanized bolt, nut and washer assemblies by the manufacturer or distributor prior to shipping. Tests on galvanized bolts and hardware shall be performed after galvanizing. Washers are required as part of the test even though they may not be required as part of the installation procedure. Except as modified herein, the rotational-capacity test shall be performed in accordance with the requirements of ASTM Designation: A 325.

The following shall apply:

- (a) Each combination of bolt production lot, nut lot and washer lot shall be tested as an assembly. Where washers are not required by the installation procedures, they need not be included in the lot identification.
- (b) A rotational-capacity lot number shall be assigned to each combination of lots tested.
- (c) The minimum frequency of testing shall be two assemblies per rotational-capacity lot.
- (d) The bolt, nut and washer assembly shall be assembled in a Skidmore-Wilhelm Calibrator or an acceptable equivalent device. For short bolts which are too short to be assembled in the Skidmore-Wilhelm Calibrator

see (h) below.

- (e) The minimum rotation, from a snug tight condition (10% of the specified proof load), shall be:

240°, 2/3 turn, for bolt lengths < 4 diameters
360°, 1 turn, for bolt lengths ≥ 4 diameters and < 8 diameters
480°, 1 1/3 turn, for bolt lengths ≥ 8 diameters

- (f) The tension reached at the above rotation shall be equal to or greater than 1.15 times the required installation tension. The installation tension and the tension for the turn test are shown below:

Diameter, inches	1/2	5/8	3/4	7/8	1	1 1/2	1 1/4	1 3/8	1 1/8
Required Installation Tension, kips	12	19	28	39	51	56	71	85	103
Turn Test Tension, kips	14	22	32	45	59	64	82	98	118

- (g) After the required installation tension listed above has been exceeded, one reading of tension and torque shall be taken and recorded. The torque value shall conform to the following:

Torque ≤ 0.25 PD

Where:

Torque = measured torque, foot-pounds
P = measured bolt tension, pounds
D = bolt diameter, feet

- (h) Bolts that are too short to test in Skidmore-Wilhelm Calibrator may be tested in a steel joint. The tension requirement of (f) above need not apply. The maximum torque requirement of (g) above shall be computed using a value of P equal to the turn test tension shown in the table in (f) above.

717.02.4--Reporting. The results of all tests, including zinc coating thickness, required herein and in the appropriate ASTM specifications shall be recorded on the appropriate document. Location where tests are performed and date of tests shall be reported on the appropriate document. The manufacturer or distributor that performs the test shall certify that the results recorded are accurate. The manufacturer shall certify that the steel and the assembly components are domestic products.

717.02.5--Documentation.

717.02.5.1--Mill Test Report(s) (MTR). MTR shall be furnished for all mill steel used in the manufacture of the bolts, nuts, and washers. MTR shall indicate

the place where the material was melted and manufactured.

717.02.5.2--Manufacturer Certified Test Report(s) (MCTR). The manufacturer of the bolts, nuts, and washers shall furnish the Department three copies of test reports (MCTR) for the items furnished. Each MCTR shall have the appropriate MTR attached. Each MCTR shall contain the information required in Subsection 717.02.4.

The manufacturer performing the rotational-capacity test shall include on the MCTR the following:

- (a) The lot number of each of the items tested.
- (b) The rotational-capacity lot number as required in paragraph (b) of Subsection 717.02.3.4.
- (c) The results of the tests required in Subsection 717.02.3.4.
- (d) The pertinent information required in Subsection 717.02.4.
- (e) A statement that MCTR for the items are in conformance to this specification and the appropriate ASTM specifications.
- (f) The location where the bolt assembly components were manufactured.

717.02.5.3--Distributor Certified Test Report(s) (DCTR). The following shall be applicable for DCTR:

- (a) The DCTR shall include MCTR above for the various bolt assembly components.
- (b) The rotational-capacity test may be performed by a distributor in lieu of a manufacturer and reported on the DCTR.
- (c) The DCTR shall show the results of the tests required in Subsection 717.02.3.4.
- (d) The DCTR shall also show the pertinent information required in Subsection 717.02.4.
- (e) The DCTR shall show the rotational-capacity lot number as required in paragraph (b) of Subsection 717.02.3.4.
- (f) The DCTR shall certify that the MCTR are in conformance to this specification and the appropriate ASTM specifications.

717.02.6--Shipping. Bolts, nuts and washers, where required, from each rotational-capacity lot shall be shipped in the same container. If there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers. Each container shall be permanently marked with the rotational-capacity lot number such that identification will be possible at any stage prior to installation.

Three copies of the appropriate MTR, MCTR or DCTR shall be furnished to the Department.

717.02.7--Final Acceptance. Final acceptance of high strength bolts, nuts, washers and direct tension indicators will be based on tests performed on samples obtained from the project by the Department. Tests will be performed in accordance with the procedures set out in these specifications. A lot shall be defined as each shipment to a project from the manufacturer's lot number and of the same size and length. The integrity of each lot shall be maintained until tests are completed by the Department.

Each lot of bolts, shall be sampled as follows:

<u>Lot Size</u>	<u>Sample Size</u>
150 or less	2
151 to 280	4
281 to 500	6
501 to 1,200	10
1,201 to 3,200	16
3,201 to 10,000	26
10,001 and over	40

Note: One-half of the sampled bolts will be used for tensile testing and the other one-half will be tested for coating and/or hardness.

Each lot of nuts or washers shall be sampled as follows:

<u>Lot Size</u>	<u>Sample Size</u>
800 or less	1
801 to 8,000	2
8,001 to 22,000	3
22,001 and over	5

Note: The sample size shall be doubled when galvanized nuts or washers are specified or used.

Each lot of direct tension indicators shall be sampled as follows:

<u>Lot Size</u>	<u>Sample Size</u>
35,000 or less	16
35,001 to 250,000	26
250,001 and over	32

Direct tension indicators shall be tested in accordance with ASTM Designation: F 959. One-half of the samples will be tested in compression and the remaining one-half will be tested for coating.

717.03--Copper Bearing Steels. When copper bearing steel is specified, the steel shall contain not less than 0.2 percent copper.

717.04--Welded Stud Shear Connectors.

- (a) Shear connector studs shall conform to the requirements of Cold Finished Carbon Steel Bars and Shafting, ASTM Designation: A 108, Cold-Drawn Bars, Grades 1015, 1018, or 1020, either semi or fully killed. If flux retaining caps are used, the steel for the caps shall be of a low carbon grade suitable for welding and shall comply with Cold-Rolled Carbon Steel Strip, ASTM Designation: A 109.
- (b) Tensile properties as determined by tests of bar stock after drawing or of finished studs shall conform to the following requirements:

Tensile Strength, minimum	60,000
Yield Strength*, minimum	50,000
Elongation, minimum	20% in 2 inches
Reduction of area, minimum	50%

* As determined by a 0.2 percent offset method.

- (c) Tensile properties shall be determined in accordance with the applicable sections of ASTM Designation: A 370, Mechanical Testing of Steel Products. Tensile tests of finished studs shall be made on studs welded to test plates. If fracture occurs outside of the middle half of the gage length, the test shall be repeated.
- (d) Finished studs shall be uniform quality and condition, free from injurious laps, fins, seams, cracks, twists, bends, or other injurious defects. Finish shall be as produced by cold drawing, cold rolling, or machining.
- (e) The manufacturer shall certify that the studs as delivered are in accordance with the material requirements of this section. Certified copies of in-plant quality control test reports shall be furnished to the Engineer upon request.

- (f) The Engineer may select, at the Contractor's expense, studs of each type and size used under the contract, as necessary for checking the requirements of this section.

717.05--Steel Grid Flooring.

717.05.1--Steel. All steel shall conform to the Specification for Structural Steel of the ASTM Designation: A 36, ASTM Designation: A 572, Grade 50, or ASTM Designation: A 588. Unless the material is galvanized, it shall have a copper content of 0.2 percent.

717.06--Pins and Rollers. Steel for pins and rollers shall conform to the designations listed in Tables I and II below.

Pins and rollers shall be accurately turned to the dimensions shown on the drawings and shall be straight, smooth, and free from flaws. Pins and rollers more than nine inches in diameter shall be forged rollers and annealed. Pins and rollers nine inches or less in diameter may be either forged and annealed or cold-finished carbon-steel shafting.

In pins larger than nine inches in diameter, a hole not less than two inches in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range, under suitable conditions to prevent injury by too rapid cooling, and before being annealed.

Table I

Minimum Material Properties Structural Steel				
Type	Structural Carbon Steel	High Strength Low-Alloy Steel		High Yield Strength Quenched and Tempered Alloy and Low Alloy Steel
Designation ASTM	A 36	A 572, Grade 50	A 588	A 514/A 517
Thickness of Plates	Up to and including 8 inches	Up to and including 4 inches	Up to and including 4 inches	Over 2½ inches up to and including 4 inches
Minimum Tensile Strength, Fu	58,000	65,000	70,000	100,000
Minimum Yield Point or Minimum Yield Strength, Fy	36,000	50,000	50,000	90,000

Table II

Minimum Material Properties Pins and Rollers				
Expansion rollers shall be not less than 4 inches in diameter				
ASTM Designation	A 108	A 668	A 668	A 668 *
Grade or Class	Grades 1016 to 1030 inclusive	Class D	Class F	Class G
Size Limitations	4 inches or less in diameter	Up to 20 inches in diameter	Up to 10 inches in diameter	Up to 20 inches in diameter
Minimum Yield, Point, psi, Fy	36,000	37,500	50,000	50,000

* May substitute rolled material of the same properties.

SECTION 718 - TIMBER AND DIMENSION LUMBER

718.01--Timber and Dimension Lumber. General. All timber and dimension lumber shall be Southern pine and shall conform in all respects to applicable requirements of AASHTO Designation: M 168. Inspection for conformance to these specifications will be conducted in accordance with Department SOP.

Timber and dimension lumber shall be furnished in the sizes shown on the plans or as specified. Unless otherwise specified, timber and dimension lumber shall be No. 1, or better, graded according to the latest American Lumber Standards.

Only one type of preservative shall be used for the treatment of materials for any one class of construction on a project, unless otherwise specified.

718.02--Untreated Timber and Dimension Lumber. Untreated timber and dimension lumber shall comply with the requirements set out in Subsection 718.01.

718.03--Treated Timber and Dimension Lumber. Timber and dimension lumber to be treated shall meet the requirements herein specified and shall be treated by a pressure method to the minimum required retainage of preservative as specified on the plans or elsewhere in the specifications. Treated timber or dimensional lumber will not be accepted for use unless it has been inspected by an authorized representative of the Department and found to be satisfactory both before and after treatment. Inspection prior to treatment may be waived by the Testing Engineer when the preservative will be pentachlorophenol or chromated copper arsenate.

718.03.1--Seasoning. Seasoning timber, dimension lumber, piles and poles to be treated with preservatives shall conform to the requirements of AWP.

718.03.2--Treatment.

718.03.2.1--General. Insofar as practicable, each charge shall consist of pieces approximately equal in size, moisture, and sapwood content into which approximately equal quantities of preservative can be injected. Each layer of material shall be separated at each end, and at the center when necessary, by strips at least 3/8 inch in thickness; caps, stringers, and other large timbers shall be separated by strips of at least 1/2-inch thickness.

All timber and lumber shall be treated in accordance with AWP treating practices unless otherwise specified herein.

Unless otherwise directed, the type and minimum quantity of preservative shall be in accordance with TABLES 1, 2 or 3.

Any treated timber or lumber to be painted shall be treated in accordance with

Subsection 718.04.3, Type B solvent, or Subsection 718.04.4.

Brackish water, as listed in TABLES 1, 2 or 3, shall mean salt waters, bordering land, and waters adjacent thereto which are subject to tidal flow.

718.03.2.2--Penetration. Unless otherwise specified, treated timber and lumber shall show a 100 percent sapwood penetration or a minimum penetration of four inches.

The test method for determining the amount of preservative retained will be either as specified in AWP or Mississippi Test Methods. The borer cores shall be obtained in accordance with AWP Standard M2 and shall be taken from pieces having a sapwood depth at least equal to the sampling zone specified as follows:

- (a) Round Units, piling and poles, shall be in accordance with AWP requirements.
- (b) Structural members less than four inches shall be from zero to one and one half inches from the surface.
- (c) All other structural members shall be from zero to two inches from the surface.

718.03.2.3--Inspection. The Department shall be notified sufficiently in advance of treating the material so that an inspector may be furnished at the plant to inspect the material and the treatment of same. All materials and processes used in the manufacture of the material shall be subject to inspection. The plant shall be equipped with the necessary gauges, thermometers, appliances, and facilities to enable the inspector to determine the conditions at all stages of the treatment and to satisfy the inspector that the requirements of the specifications are fulfilled. The manufacturer shall also provide the apparatus and chemicals necessary for making tests at the plant as required by the Department. All equipment, apparatus, etc., shall be maintained in proper and satisfactory condition for use at all times.

Tests for penetration of preservative shall be made with an increment borer. Test holes shall be plugged with treated plugs. All borings shall be taken at the center of the narrow side of the piece. Sufficient borings shall be taken to insure that the specified penetration has been obtained, with a minimum of 20 borings required for each charge of materials.

If 20% or more of the borings from a charge of treated material fail to meet the penetration requirements, the entire charge shall be rejected and subject to retreatment. If upon retreatment, the material meets the penetration requirements, it will be accepted. Only one retreatment will be permitted, and

any apparent damage due to retreatment shall be cause for rejection.

718.03.3--Handling Treated Material. Any bruising or rough handling will be cause for rejection.

718.03.4--Storage of Treated Material. All material treated for stock shall be stacked as compactly as possible on a well-drained surface. Material shall be supported on sills spaced as necessary, not to exceed 10 foot intervals and shall have at least one foot of air space beneath the stacks.

All materials treated with CCA for use in buildings and applications where painting is required shall be dried after treatment. The treated wood shall be kiln dried by American Lumber Standards, or air dried for a period of at least 21 days before shipment.

718.04--Preservative. The preservatives shall meet the applicable requirements of AWWA, and the water content in an oil preservative shall not exceed 3.0% unless otherwise approved by the Engineer; but in no case shall it exceed 5.0%.

718.04.1--Creosote Oil. The creosote oil shall meet the requirements of AWWA P-1. The test methods shall be either AWWA or Mississippi Test Methods.

718.04.2--Creosote-Coal Tar Solution. The creosote coal tar solution shall meet the requirements of AWWA P-2. The test methods shall be either AWWA or Mississippi Test Methods.

718.04.3--Pentachlorophenol. The pentachlorophenol shall meet the requirements of AWWA P-8. The test methods shall be either AWWA or Mississippi Test Methods.

The hydrocarbon solvent used in the pentachlorophenol solution shall meet the requirements of AWWA P-9, Type A or B. When painting is required, Type B solvent shall be used. Type A solvent shall be used for all other treatment unless otherwise specified.

718.04.4--Chromated Copper Arsenate (CCA). The solution shall contain a sufficient concentration of the water-born preservative to produce the minimum specified retention. The preservative shall meet the requirements of AWWA P-5, CCA Type B or C. The test methods shall be either AWWA or Mississippi Test Methods.

TABLE 1
Minimum Treatment Rates For Creosote,
and Creosote-Coal Tar Preservatives

Material	Coastal Area and Brackish Water		Other Locations	
	Retention pounds / cubic foot	Preservative Required	Retention pounds / cubic foot	Preservative Required
Lumber (1)	20	(3)	12	(2) or (3)
Piling	20	(3)	12	(2) or (3)
Poles	9	(2) or (3)	9	(2) or (3)

- Notes: (1) Lumber in the Coastal Area which will not be in contact with brackish water may be treated as specified for "Other Locations".
(2) Creosote conforming to Subsection 718.04.1.
(3) Creosote-Coal Tar conforming to Subsection 718.04.2.

TABLE 2
Minimum Treatment Rates For Pentachlorophenol Preservative
conforming to Subsection 718.04.3

Material	Coastal Areas and Brackish Water	Other Locations
	Retention pounds / cubic foot	Retention pounds / cubic foot
Lumber	(1)	0.80
Piling	Penta Not Permitted	0.80
Poles	0.60	0.60
Material to be Painted	(2)	(2)

- Notes: (1) Pentachlorophenol not permitted for lumber which will be in contact with brackish water. Lumber in the Coastal Area which is not in contact with brackish water may be treated as specified for "Other Locations".
(2) Treated at the rate specified above using AWWA P-9, Type B Solvent.

TABLE 3
Minimum Treatment Rate For Chromated Copper Arsenate Preservative
conforming to Subsection 718.04.4

Material	Coastal Areas and Brackish Water	Other Locations
	Retention pounds / cubic foot	Retention pounds / cubic foot
Lumber (1)	2.50	0.80
Piling	2.50	0.80
Poles	0.60	0.60

Notes: (1) Lumber in the Coastal Area which is not in contact with brackish water may be treated as specified for "Other Locations".

SECTION 719 - PILES

719.01--General. Piles shall be untreated timber, treated timber, precast concrete, cast-in-place concrete, or steel piles, as specified and in addition to the general requirements of these specifications and the plans, shall conform to the specific requirements hereinafter set forth, unless otherwise stipulated.

719.02--Timber Piles. All piles shall conform to the requirements of ASTM Designation: D 25, except as hereinafter specified. Inspection for conformance to these specifications will be conducted in accordance with Department SOP.

The circumference and diameters of piling shall be in conformity with Table I.

719.02.1--Untreated Timber Piles. Untreated timber piles may be any species which will satisfactorily withstand driving. They shall be reasonably clean-peeled.

719.02.2--Treated Timber Piles. Treated timber piles shall be Southern Pine preferably cut during the winter season. Treated timber piles shall be inspected and treated in accordance with the requirements set forth in Section 718.

TABLE I
CIRCUMFERENCES AND DIAMETERS OF TIMBER PILES

	Three Feet From Butt				At Tip	
	Minimum		Maximum		Minimum	
Length	Circum- ference	Approx. Diameter	Circum- ference	Approx. Diameter	Circum- ference	Approx. Diameter
Feet	inches	inches	inches	inches	inches	inches
Under 40	38	12	63	20	25	8
40 to 50*	38	12	63	20	22	7
51 to 70*	41	13	63	20	22	7
70 to 90*	41	13	63	20	19	6
Over 90	44	14	63	20	19	6
* inclusive						

719.03--Concrete Piles. Concrete piles, both prestressed and cast-in-place, shall be constructed in conformity with the plans and in accordance with these specifications. Additional requirements for prestressed piles are set out in Section 803.

All concrete materials and their preparation and placing shall be in accordance with the requirements of the class of concrete specified and in accordance with Section 803.

Reinforcing steel shall conform to the requirements of Section 711.

719.04--Steel Piles. The material in rolled steel piles shall be standard structural grade steel of the section number, size, and weight per linear foot indicated on the plans. The steel shall conform to the requirements of ASTM Designation: A 36.

The Contractor shall furnish the State Materials Engineer three certified copies of the mill test reports containing the true chemical and physical analyses of the material.

719.05--Steel Sheet Piling. Steel sheet piling shall conform to the requirements of ASTM Designation: A 328.

The Contractor shall furnish the State Materials Engineer with three certified copies of the mill test reports containing the true chemical and physical analyses of the material.

SECTION 720 - PAVEMENT MARKING MATERIALS

720.01--Glass Beads. The beads shall be transparent, clean, colorless glass, smooth and spherically shaped, free from milkiness, pits, or excessive air bubbles and conform to the specific requirements for the class designated. Unless otherwise specified, Class A glass beads shall be furnished.

720.01.1--Class A. The Class A, Standard, beads shall be Type 1, non-flotation with a moisture resistant coating conforming to the requirements of AASHTO Designation: M 247.

720.01.2--Class B. The Class B, High-Visibility, beads shall be non-flotation, embedment coated and conform to the following specific requirements.

720.01.2.1--Gradation. The beads shall meet the gradation requirements of Table 1.

Table 1

U.S. Standard <u>Sieve No.</u>	<u>% Retained</u>
12	0
14	0-5
16	5-20
18	40-80
20	10-40
25	0-5
Pan	0-2

720.01.2.2--Roundness. The beads shall have a minimum of 80 percent rounds per screen for the two (2) highest sieve quantities. The remaining sieve fractions shall be no less than 75 percent rounds.

720.01.2.3--Angular Particles. The beads shall have no more than three (3) percent angular particles per screen.

720.01.2.4--Refractive Index. The beads shall have a refractive index of 1.50 to 1.52.

720.01.3--Packaging and Marking. The beads shall be packaged in 50 or 55-pound moisture proofed bags. Each bag shall be stamped with the following information: name and address of manufacturer, shipping point, trademark or name, the wording "glass beads", class, weight, lot number and the month and year of manufacture.

720.01.4--Acceptance Procedures. The manufacturer shall furnish the MDOT Central Laboratory three copies of the certified test report(s) showing results of

all required tests and certification that the material meets the specifications. Acceptance sampling and testing of glass beads will be in accordance with MDOT S.O.P. No. TMD-40-02-00-000.

720.02--Thermoplastic Pavement Markings. The thermoplastic material shall conform to AASHTO Designation: M 249 except the glass beads shall be moisture resistant coated.

The manufacturer/producers of the thermoplastic compound, glass beads, epoxy resin, and primer/sealer shall furnish to the Engineer three copies of certified test reports showing results of all tests specified therein and shall further certify that the materials meet all requirements.

720.03--Raised Pavement Markers.

720.03.1--General. Raised pavement markers, including high performance raised pavement markers, shall be listed on the Department's "Approved Sources of Materials".

720.03.2--Type of Markers. Pavement and jiggle markers shall conform to one or more of the following types:

- Type A Non-Reflective White Jiggle Markers
 - Class 1 Acrylonitrile-Butadiene-Styrene Polymer Markers
 - Class 2 Ceramic Markers
- Type AY Non-Reflective Yellow Jiggle Markers
 - Class 1 Acrylonitrile-Butadiene-Styrene Polymer Markers
 - Class 2 Ceramic Markers
- Type B 2-Way Clear Reflective Markers
- Type C Red-Clear Reflective Markers
- Type D 2-Way Yellow Reflective Markers
- Type E One-Way Clear Reflective Markers
- Type F One-Way Yellow Reflective Markers
- Type G Yellow-Clear Reflective Markers
- Type H Chip Seal Clear Reflective Markers
- Type I Chip Seal Yellow Reflective Markers

High performance raised pavement markers shall be available in Types B through G.

720.03.3--Acceptance Procedures.

720.03.3.1--Marker Type A. The Contractor shall furnish the Engineer three copies of the manufacturer's certified test reports covering all pavement markers shipped to the project. The certified test report shall show the test results on each part of each section contained in Mississippi Test Method MT-17 and shall state

that the markers represented by the test results comply with the specifications contained herein in all respects.

The pavement markers will be tentatively accepted on the basis of the manufacturer's certified test reports. Final acceptance shall be based on check samples as set out in Subsection 720.03.4.

720.03.3.2--Marker Type B through G. The Contractor shall furnish the Engineer three copies of the manufacturer's certification covering all pavement markers shipped to the project. The certification shall state that the raised pavement markers meet the applicable requirements of ASTM Designation: D 4280.

The pavement markers will be tentatively accepted on the basis of the manufacturer's certification. The Department reserves the right to obtain check samples as deemed necessary for determining compliance with this specification.

720.03.3.3--Marker Type H and I. Prior to use, the Contractor shall furnish the Engineer three copies of a certification for each shipment stating that the material furnished is of the same composition as that originally approved by the Department and that the material has not been changed or altered in any way. The Department will obtain check samples as deemed necessary for determining compliance with this specification.

720.03.4--Sampling, Tolerances, and Packaging. Pavement markers shall conform to sampling, tolerance, and packaging requirements as set out below.

720.03.4.1--Sampling. For Marker Type A, H and I, ten (10) markers of each type and class, selected at random, will constitute a representative sample for each lot regardless of lot size.

For Marker Type B through G, check sampling, when performed, shall require ten (10) markers of each type, selected at random, to constitute a representative sample for each lot regardless of lot size.

A resample of any marker type will consist of twice as many markers as originally sampled.

720.03.4.2--Tolerances.

720.03.4.2.1--Tolerances For Marker Type A, H & I. At least 90% of the original sampling of each lot of markers shall pass all tests with the following exceptions:

When less than 90% but more than 70% pass all tests, a resample of that lot will be allowed at the request of the Contractor. When less than 70% of the markers from the original sample comply with the requirements, the lot

represented by the samples will be rejected and no resample will be allowed. Tolerances for resamples shall be in the same ratio as specified above.

At least two of three specimens, randomly selected for strength, water absorption, and autoclave, and also the averages of the three, must pass the stated requirements; otherwise, three additional markers selected at random shall be tested, and if the same conditions for passing are not met for these latter three markers, the lot will be rejected.

720.03.4.2.2--Tolerances For Marker Type B through G. At least 90% of the check sampling of each lot of markers shall pass the strength test required in the Physical Properties Section of ASTM Designation: D 4280 with the following exceptions:

When less than 90% but more than 70% pass the test, a resample of that lot will be allowed at the request of the Contractor. When less than 70% of the markers from the check sample comply with the requirements, the lot represented by the samples will be rejected and no resample will be allowed. Tolerances for resamples shall be in the same ratio as specified above.

720.03.4.3--Packaging. Shipments shall be made in containers which are acceptable to common carriers and packaged in such a manner as to insure delivery in perfect condition. All damaged shipments shall be replaced by the Contractor.

Each package shall be clearly marked as to the name of the manufacturer, type, quantity enclosed, lot number, and date of manufacture.

720.03.5--Non-Reflective Pavement Markers. Non-reflective jiggle markers shall be either Class 1 or Class 2. Markers shall be approved products as listed on the Department's "Approved Sources of Materials" for jiggle bar markers.

720.03.5.1--Class 1 Markers. Class 1 non-reflective jiggle markers shall consist of an acrylonitrile-butadiene-styrene polymer or other approved material, and shall be 4 inches wide x 6 inches long. Infrared curves of materials used in markers shall match approved curves on file at the Central Laboratory.

Class 1 markers shall conform to the following requirements when tested in accordance with Mississippi Test Method: MT-17.

<u>Property</u>	<u>Requirement</u>
Heat Resistance	No change in shape or appearance
Impact Resistance	No break, chip or crack
Load Resistance	No break, chip, crack or permanent deformation

720.03.5.2--Class 2 Markers. Class 2 non-reflective jiggle markers shall consist

of a heat-fired, vitreous, ceramic base, and a heat-fired, opaque, glazed surface to produce the properties required in these specifications. The bottom of the marker shall not be glazed. The markers shall be produced from any suitable combination of intimately mixed clays, shales, talcs, flints, feldspars, or other inorganic material which will meet the properties herein required. The markers shall be thoroughly and evenly matured and free from defects which affect appearance or serviceability.

Non-reflective markers shall conform to the following finish and testing requirements:

The top surface of the marker shall be in reasonably close conformity with the configuration shown on the plans. All edges shall be rounded and any change in curvature shall be gradual. The top and sides shall be smooth and free of mold marks, pits, indentations, air bubbles, or other objectionable marks or discolorations. The base of all markers shall be flat. The deviation from a flat surface shall not exceed 0.05 inch and shall be free from gloss glaze or substances that may reduce its bond to the adhesive.

All tests shall be performed in accordance with Mississippi Test Method: MT-17, which will be on file in the Materials Division.

<u>Test</u>	<u>Requirement</u>
Glaze thickness	0.005 inch minimum
Moh Hardness	6 minimum
Directional reflectance, Type A, white markers only	
Glazed Surface	75 minimum
Body of Marker	70 minimum
Yellowness Index, Type A, white markers only	
Glazed Surface	0.07 maximum
Body of Marker	0.12 maximum
Color, Type AY, yellow markers only,	
FHWA Highway Yellow Color Tolerance Chart	PR Color # 1
Autoclave	Glaze shall not spall, craze, or peel
Compressive Loading	750 pounds, minimum
Water Absorption	2.0% maximum

720.03.6--Reflective Pavement Markers. Reflective pavement markers shall be listed on the Department's "Approved Sources of Materials" and shall meet the

applicable requirements of ASTM Designation: D 4280.

720.03.7--Adhesive for Pavement Markers.

720.03.7.1--General Requirements. The adhesive shall be an asphaltic or thermoplastic material suitable for bonding pavement markers to portland cement concrete pavement, hot bituminous pavement and chip-sealed surfaces when the road surface and marker temperatures are in the range of 50°F to 160°F. The composition of the adhesive must be such that its properties will not deteriorate when heated to and applied at temperatures up to 425°F using either air or oil-jacketed melters.

720.03.7.2--Specific Requirements. In addition to the specific requirements set forth herein, the adhesive shall be listed on the Department's "Approved Sources of Materials" prior to its use.

720.03.7.3--Packaging and Labeling. The adhesive shall be packaged in self-releasing cardboard containers which will stack properly. The label shall show the manufacturer, quantity, and lot or batch number. "Adhesive for Pavement Markers" or "Adhesive for Traffic Markers" shall be printed in bold lettering on the label.

720.03.7.4--Sampling. A minimum of 10 pounds of adhesive per lot or batch received shall be submitted to the State Materials Engineer for compliance testing. This may be submitted in the form of an adhesive testing package from each batch or material obtained from a package shipped to the project.

720.03.7.5--Manufacturer's Certified Test Report. The adhesive will be tentatively accepted by a manufacturer's certified test report. The certified test report shall show the test results and shall state that the adhesive represented by the test results meets all the requirements of the contract and has the properties and characteristics as herein specified. It shall be the Contractor's responsibility to furnish three copies of the manufacturer's test report for each batch of adhesive shipped to the project.

720.03.7.6--Bituminous Adhesive, Standard Type. The asphaltic material and mineral filler shall comply with the following requirements:

(a) Adhesive Properties:

	<u>Minimum</u>	<u>Maximum</u>	<u>Test Method</u>
Softening Point, °F	200	-	ASTM: D 36
Penetration @ 77°F	10	20	ASTM: D 5
Flow, inch	-	0.2	MT-73
Heat Stability Flow, inch	-	0.2	MT-73
Viscosity, 400°F, Poises	-	75	MT-73
Flash Point, C.O.C., °F	550	-	ASTM: D 92

(b) Asphalt properties determined on the filler-free material derived from the extraction and Abson recovery process as explained in Mississippi Test Method MT-73.

	<u>Minimum</u>	<u>Maximum</u>	<u>Test Method</u>
Penetration, 100 g, 5 sec, 77°F	25	-	ASTM: D 5
Viscosity, 275°F, Poises	12	-	ASTM: D 2171
Viscosity Ratio, 275°F	-	2.2	MT-73

(c) Filler properties determined using the filler separation technique described in Mississippi Test Method MT-73.

	<u>Minimum</u>	<u>Maximum</u>	<u>Test Method</u>
Filler Content, percent by weight	50	75	MT-73
Filler Fineness, percent passing:			
Sieve No. 100	100	-	MT-73
Sieve No. 200	90	-	MT-73
Sieve No. 325	75	-	MT-73

720.03.7.7--Flexible Adhesive. The hot applied flexible pavement marker adhesive shall be a hot melt thermoplastic material capable of bonding the marker without excessive marker movement at hot summer temperatures and remain flexible at winter temperatures. The adhesive shall comply with the following physical requirements when melted in accordance with ASTM Designation: D 3407 and poured into suitable test molds:

<u>Test</u>	<u>Result</u>	<u>Test Method</u>
Penetration, 77°F	25 max.	ASTM Designation: D 5
Softening point	200°F min.	ASTM Designation: D 36
Brookfield viscosity, 400°F	10,000 cp max.	ASTM Designation: D 3236
Ductility @ 77°F, 5 cm/min	15 cm min.	ASTM Designation: D 113
Ductility @ 39.2°F, 1 cm/min	5 cm min.	ASTM Designation: D 113
Asphalt Compatibility	Pass	ASTM Designation: D 5329
Flexibility	Pass at 20°F	Per Subsection 720.03.7.8

720.03.7.8--Test Procedure for Flexibility.

Sample Preparation - One-eighth inch thick steel shims are used to enclose an opening which is one-inch wide and four-inches long on a sheet of release paper or a release treated metal plate. The heated adhesive is poured into the opening until it is slightly overfilled. After one hour of cooling the excess adhesive is trimmed flush with the shims using a hot knife and then the sample is removed from the shims.

Conditioning - The trimmed samples are placed in a freezer maintained at 20 ±2°F for a minimum of four hours.

Testing - The conditioned samples are removed from the freezer and immediately bent over a one-inch diameter mandrel through an arc of 90 degrees in 10 seconds at a uniform rate of nine degrees per second. A passing result is one in which no cracking occurs in the test sample. At least two of the three specimens tested must meet the flexibility requirement at 20°F for a passing result.

720.04--Cold Plastic Pavement Markings.

720.04.1--General. The prefabricated markings described shall consist of white or yellow pigmented plastic films with reflective glass spheres uniformly distributed throughout their entire cross-sectional area, and be capable of being affixed to bituminous or portland cement concrete pavements by either a pressure sensitive precoated adhesive or a liquid contact cement. The markings shall be provided complete in a form that will facilitate rapid application and protect the markings in shipment and storage. The manufacturer shall identify proper solvents and/or adhesives to be applied at the time of application, all equipment necessary for proper application, and recommendations for application that will assure an effective performance life.

Prefabricated legends and symbols shall conform to the applicable shapes and sizes as outlined in the current "Manual on Uniform Traffic Control Devices."

Cold plastic pavement markings shall be listed on the Department's "Approved Sources of Materials". Prior to use, the Contractor shall furnish the Engineer three copies of the manufacturer's certification for each shipment stating that the material furnished is of the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

720.04.2--Requirements. Unless otherwise indicated on the plans, the material shall be 60 mil retroreflective pliant polymer film.

720.04.2.1--Composition. The retroreflective pliant polymer pavement marking film shall consist of a mixture of high quality polymeric materials, pigments, 1.5 index glass beads uniformly distributed throughout its cross sectional area and with a reflective layer of beads bonded to the top surface. The film shall be composed of the following materials:

<u>Material</u>	<u>Minimum Percent by Weight</u>
Resins & Plasticizers	20
Pigments	30
Graded Glass Beads	33

This film shall be capable of being fabricated into pavement markings of specified thickness and dimensions and of being adhered to asphaltic and/or portland cement concrete by means of a pressure sensitive precoated adhesive, or a liquid contact cement which is applied at the time of installation.

720.04.2.2--Conformability and Resealing. The retroreflective pliant polymer pavement marking film shall be capable of conforming to pavement contours, breaks, faults, etc. through the action of traffic at normal pavement temperatures. The film shall have resealing characteristics such that it is capable of fusing with itself and previously applied marking film of the same composition under normal conditions of use.

The film shall show patchability when tested as follows:

- (a) Cut two 1-inch x 3-inch pieces of the pliant polymer and mark the reflective side of one of the pieces with a pencil to delineate a 1-inch x 1-inch area at the end of the piece.
- (b) Wet the surface of the area delineated with a cloth soaked in contact cement or a mixture of MEK and toluene for one minute, keeping the surface wet. At the end of one minute, scrape the beads and binder off the sample and wipe the residual binder from the area. Let the sample dry for at least one minute.
- (c) Remove the liner from the back of the second piece of film and place the backside on top of the cleaned area on the first piece. The sample, while held together, should now form one piece four inches long by one inch wide with the 1-inch x 1-inch overlap patch in the center.
- (d) Place the patched sample on a hard surface under 1,000 grams per square inch, the area of the overlap splice, maintained at 140°F for two hours.
- (e) Remove the sample from the heat and allow to cool to 70°F, room temperature.
- (f) Pull the sample in opposite directions to place a shear strain on the patched area. The two pieces shall not separate without tearing.

720.04.2.3--Tensile Strength. The film shall have a minimum tensile strength of 40 pounds per square inch of cross section when tested according to ASTM Designation: D 638. A 6-inch x 1-inch x 0.06-inch sample shall be tested at a

temperature between 70°F and 80°F using a jaw speed of 12 inches per minute.

720.04.2.4--Elongation. The film shall have a minimum elongation of 75% at break when tested according to ASTM Designation: D 638 using a jaw speed of 12 inches per minute.

720.04.2.5--Plastic Pull Test. A test specimen made the same size as in Subsection 720.04.2.3 shall support a dead weight of four pounds for not less than five minutes at a temperature between 70°F and 80°F.

720.04.2.6--Pigmentation. The pigments shall be selected and blended to provide a marking film which is white or yellow conforming to standard highway colors through the expected life of the film.

720.04.2.7--Glass Beads. The glass beads shall be colorless and have a minimum index of refraction of 1.50 when tested using the liquid oil immersion method. The size and quality of the beads will be such that performance requirements for the retroreflective pliant polymer film shall be met.

Bead adhesion shall be such that beads are not easily removed when film surface is scratched firmly with thumbnail.

The film shall have glass bead retention qualities such that when a 2-inch x 6-inch sample is bent over a 1/2-inch diameter mandrel, with the 2-inch dimension perpendicular to the mandrel axis, microscopic examination of the area on the mandrel shall show no more than 10% of the beads with entrapment by the binder of less than 40%.

720.04.2.8--Skid Resistance. The surface of the retroreflective pliant polymer film shall provide a minimum skid resistance value of 35 BPN when tested according to ASTM Designation: E 303.

720.04.2.9--Reflective Intensity. The photometric quantity to be measured shall be specific luminance and shall be expressed as millicandelas per square foot per foot candle. The minimum initial reflective values shall be 250 for white and 200 for yellow as measured in accordance with Mississippi Test Method MT-70.

720.04.2.10--Reflectivity Retention. The following tests shall be employed to measure reflectivity retention:

- (a) **Taber Abraser Simulation Test.** Using a taber abraser with an H-18 wheel and a 125-gram load, the sample shall be inspected at 200 cycles, under a microscope, to observe the extent and type of bead failure.

No more than 15% of the beads shall be lost due to pop-out and the predominant mode of failure shall be "wear down" of the beads.

- (b) Qualitative Tests.** Bead bond strengths shall be judged under a microscope with a magnification of at least 5X. The beads shall be difficult to remove, and when removed, beads shall show a portion of the polymeric bead bond retained with the beads rather than clean removal from the sockets.

720.04.2.11--Thickness. Unless otherwise indicated on the plans, the retroreflective pliant polymer film, without adhesive, shall be supplied in a standard thickness of 0.06 inch.

720.04.2.12--Effective Performance Life. The film, when applied according to the recommendations of the manufacturer, shall provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. Although reflectivity is reduced by wear, the pliant polymer shall provide a cushioned, resilient substrate that reduces bead crushing and loss. The film shall be weather resistant and, through normal traffic wear, shall show no appreciable fading, lifting or shrinkage throughout the useful life of the marking, and shall show no significant tearing, roll back, or other signs of poor adhesion.

720.04.3--Manufacturer's Certification. The Contractor shall furnish the Engineer three copies of the manufacturer's certification stating that each lot in a shipment complies with the requirements of the contract.

720.04.4--Acceptance Sampling and Testing. Final acceptance of each lot will be based on results of tests performed by the Department on verification samples submitted from each lot shipped to the project. The Engineer will select one sample at random from each lot in the shipment for testing. A sample extending full width of the randomly selected sample and five linear feet in length will be obtained and submitted by the Engineer. The sample from each shipment shall be provided at no cost to the State.

720.05--Preformed Pavement Markings for Construction Zones.

720.05.1--General. In addition to the specific material requirements set forth herein, pavement marking materials must have been approved for listing in the Department's "Approved Sources of Materials" prior to their use.

The preformed markings shall consist of retroreflective materials on a conformable backing. The pigments shall be selected and blended to provide pavement markings which conform to standard highway colors.

The size, quality, and refractive index of the glass beads shall be such that the performance requirements for the markings will be met. The bead adhesion shall be such that beads are not easily removed when the material surface is scratched with a thumbnail.

The markings shall be precoated with a pressure sensitive adhesive capable of adhering to asphalt and portland cement concrete pavement in accordance with the manufacturer's instructions without the use of heat, solvents or other additional adhesives. The markings and/or adhesive shall not require any curing time after application.

The markings shall be provided in specified widths and shapes. Preformed words and symbols shall conform to the applicable shapes and sizes as outlined in the current "Manual on Uniform Traffic Control Devices for Streets and Highways," or as modified.

The materials shall be packaged in accordance with accepted commercial standards and when stored indoors in a cool dry place, shall be suitable for use one year after date of purchase.

720.05.2--Classification of Markings. Retroreflective preformed pavement markings shall be of the following types, as specified on the plans or in the contract documents:

720.05.2.1--Type 1. The markings shall consist of a mixture of high quality polymeric materials, pigments and glass beads with a reflective layer of beads bonded to the top surface. A non-metallic medium coated with a pressure sensitive adhesive shall be incorporated to facilitate removal. The adhesive shall be of a type that is completely removed with the pavement marking or colorless so as not to leave a color mark on the pavement.

Reflectance. The markings shall meet or exceed the initial reflectance values when measured in accordance with the testing procedures of ASTM Designation: D 4592.

INITIAL REFLECTANCE VALUES

	<u>White</u> 86°		<u>Yellow</u> 86°	
Entrance Angle	0.2°	0.5°	0.2°	0.5°
Observation Angles	1770	1270	1310	820
SL (mcd/ft ² /fc)				

The photometric quantity to be measured shall be specific luminance (SL) and shall be expressed in millicandelas per square foot per footcandle. The test distance shall be 50 feet, and the sample size shall be a 2.0 x 2.5-foot rectangle. The angular aperture of both the photoreceptor and light projector shall be six minutes of arc. The reference center shall be the geometric center of the sample, and the reference axis shall be taken perpendicular to the test sample.

The quantity SL (specific luminance) treats the retroreflector as a surface source rather than a point source whose projected area is visible as an area at the

observation position. The quantity SL related to the way the effective retroreflective surface is focused on the retina of the human eye and to the visual effect thereby produced. It is recommended for describing the performance of highway signs and striping, or large vehicular markings which are commonly viewed as discernable surface areas.

720.05.2.2--Type 2. The pavement markings shall consist of retroreflective materials on a conformable metallic backing, precoated with a pressure sensitive adhesive which is colorless so as not to leave a color mark on the pavement or of a type that is substantially removed with the pavement marking.

Reflectance. The markings shall meet or exceed the initial reflectance values when measured in accordance with the testing procedures of ASTM Designation: D 4592.

INITIAL REFLECTANCE VALUES

	<u>White</u> 86°		<u>Yellow</u> 86°	
Entrance Angle				
Observation Angles	0.2°	0.5°	0.2°	0.5°
SL (mcd/ft ² /fc)	1360	760	820	510

The sample size, test procedure and measurement of test values shall be as prescribed for Type 1 in 720.05.2.1.

720.05.3--Certificates of Compliance. The Contractor shall furnish the Engineer three copies of certifications from the manufacturer for each lot of pavement markings stating that the material meets the requirements of the contract.

720.06--Preformed Permanent Foil Tape. Preformed foil tape shall be one from the Department's "Approved Sources of Materials". Prior to use, the Contractor shall furnish the Engineer three copies of a certification for each shipment stating that the material is of the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

720.07--High Performance Cold Plastic Pavement Markings.

720.07.1--General. The preformed high performance pavement markings shall consist of white or yellow films with ceramic beads incorporated to provide immediate and continuing retroreflection.

Preformed high performance cold plastic pavement markings shall be listed on the Department's list of "Approved Sources of Materials" for Preformed High Performance Profile Cold Plastic Pavement Marking Tape. Prior to use, the

Contractor shall furnish the Engineer three copies of the manufacturer's certification for each shipment stating that the material furnished is of the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

The preformed pavement markings shall be capable of being adhered to the pavement by a pre-coated pressure sensitive adhesive. A primer may be used to precondition the pavement surface. When a primer is specified by the manufacturer, it shall be installed as recommended by the manufacturer at no additional cost to the State. The preformed pavement markings shall conform to pavement contours by the action of traffic. After application, the markings shall be immediately ready for traffic. A representative of the manufacturer shall be present to identify proper solvents and/or primers, where necessary, to be applied at the time of application, to identify all equipment necessary for proper application, and to make recommendations for application that will assure effective product performance.

720.07.2--Classification. The preformed pavement markings shall be highly durable retroreflective pliant polymer materials designed for longitudinal markings subjected to high traffic volumes.

720.07.3--Requirements.

720.07.3.1--Composition. The retroreflective pliant polymer pavement marking film shall consist of a mixture of high quality polymeric materials, pigments and glass beads distributed throughout its base cross-sectional area, with a reflective layer of ceramic beads bonded to a durable polyurethane top surface. The surface shall have approximately 50 ±15% of the surface area raised and presenting a near vertical face angle of 0° to 60° to traffic from any direction. The channels between the raised areas shall be substantially free of exposed beads or particles.

720.07.3.2--Retroreflectance. The white and yellow markings shall have the following initial minimum retroreflectance values as measured in accordance with the testing procedures of ASTM Designation: D 4061. The photometric quantity to be measured shall be coefficient of retroreflected luminance (R_L), and shall be expressed as millicandelas per square foot per foot-candle ($\text{mcd}/\text{ft}^2/\text{fc}$).

INITIAL MINIMUM RETROREFLECTANCE VALUES

	White		Yellow	
Entrance Angle	86.0°	86.5°*	86.0°	86.5°*
Observation Angle	0.2°	1.0°	0.2°	1.0°
Retroreflected Luminance, R_L ($\text{mcd}/\text{ft}^2/\text{fc}$)	1100	700	800	500

* These retroreflectance values are based on dark room photometric readings

per ASTM D 4061. The Ecolux™ Retroreflectometer measurement geometry is an 86.5° entrance angle and a 1.0° observation angle.

720.07.3.3--Glass Beads. The size and quality of the beads shall be such that the performance requirements for the retroreflective pliant polymer shall be met.

720.07.3.3.1--Index of Refraction. All ceramic beads bonded to the polyurethane coated patterned surface of the material shall have a minimum index of refraction of 1.70 when tested using the liquid oil immersion method. The glass beads mixed into the pliant polymer shall have a minimum index of refraction of 1.5 when tested by the liquid oil immersion method.

TESTING PROCEDURE FOR REFRACTIVE INDEX OF BEADS BY LIQUID IMMERSION

EQUIPMENT REQUIRED:

- A. Microscope, minimum 100X magnification
- B. Light Source - preferably sodium light or other monochromatic source, but not absolutely essential
- C. Refractive Index Liquids*
- D. Microscope Slide and Slide Cover
- E. Mortar and Pestle

* Available from R.P. Cargille Laboratories, Inc., Cedar Grove, NJ

PROCEDURE:

- A. Using the mortar and pestle, crush a few representative beads and place a few of these crushed particles on a microscope slide.
- B. Place a drop of a refractive index liquid, with an index as close to that of the glass as can be estimated, on the crushed bead particles.
- C. Cover the slide with a microscope slide cover and view the crushed particles by transmitted light normal to the slide surface by illumination from the bottom.
- D. Adjust the microscope mirror to allow a minimum light intensity for viewing. This is important when sodium light is not used.
- E. Bring a relatively flat and transparent particle into focus.
- F. By slightly raising and lowering the microscope tube, look for one or both of the following:
 - 1. Becke Line - This light line will appear to move either into the particle or away from it. In general, when the microscope tube is raised, the line will move toward the material of higher refractive index; when the microscope tube is lowered, the line will move toward the material of lower index.
 - 2. Variation in Particle Brightness - When raising the microscope tube from sharp focus, the particle will appear to get brighter or darker than the surrounding field. If it becomes brighter, the glass has a higher refractive index than the liquid. If it becomes darker, the

glass has a lower refractive index than the liquid. In both cases, the opposite will be true when the microscope tube is lowered.

- G. This test can be used to confirm that the beads are above or below a specified index. It can also be used to give an accurate determination of the index, ± 0.001 . This is done by using several refractive index liquids until a match or near match of indices occurs. The index of the glass will equal that of the liquid when no Becke line and no variation in bead brightness can be observed.

720.07.3.3.2--Acid Resistance. The beads shall show resistance to corrosion of their surface after exposure to a 1% solution by weight of sulfuric acid. The 1% acid solution shall be made by adding 5.7 mL of concentrated acid into 1000 mL of distilled water. **CAUTION:** Always add the concentrated acid into the water, not the reverse. The test shall be performed as follows:

Take a 1" x 2" sample, adhere it to the bottom of a glass tray and place just enough acid solution to completely immerse the sample. Cover the tray with a piece of glass to prevent evaporation and allow the sample to be exposed for 24 hours under these conditions. Then decant the acid solution, but do not rinse, touch, or otherwise disturb the bead surfaces, and dry the sample while adhered to the glass tray in a 150°F oven for approximately 15 minutes.

Microscopic examination at 20X shall show no more than 15% of the beads having a formation of a very distinct opaque white, corroded, layer on their entire surface.

720.07.3.4--Color. The preformed pavement markings shall consist of white and yellow films with pigments selected and blended to conform to standard highway colors.

720.07.3.5--Skid Resistance. The patterned surface of the retroreflective pliant polymer shall provide an initial average skid resistance value of 45 BPN when tested according to ASTM Designation: E 303, except values will be taken at downweb and at a 45 degree angle from downweb. These two values will then be averaged to find the skid resistance of the patterned surface.

720.07.3.6--Patchability. The pavement marking material shall be capable of use for patching worn areas of the same type in accordance with manufacturer's instructions.

720.07.3.7--Thickness. The patterned material, without adhesive, shall have a minimum caliper of 0.065 inch at the thickest portion of the patterned cross-section and a minimum caliper of 0.020 inch at the thinnest portion of the cross-section.

720.07.4--Effective Performance Life. The film, when applied according to the

recommendations of the manufacturer, shall provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. The film shall be weather resistant and, through normal traffic wear, shall show no appreciable fading, lifting or shrinkage throughout the useful life of the marking, and shall show no significant tearing, roll back, or other signs of poor adhesion.

720.07.5--Manufacturer's Certification. The Contractor shall furnish the Engineer three copies of the manufacturer's certification stating that each lot in a shipment complies with the requirements of the contract.

720.07.6--Acceptance Sampling and Testing. Final acceptance of each lot will be based on results of tests performed by the Department on verification samples submitted from each lot shipped to the project. The Engineer will select one sample at random from each lot in the shipment for testing. A sample extending full width of the randomly selected sample and five linear feet in length will be obtained and submitted by the Engineer. The sample from each shipment shall be provided at no cost to the State.

720.07.7--Warranty. All manufacturer's standard warranties and guarantees on high performance cold plastic pavement marking material, which are provided as customary trade practice, shall be delivered to the Engineer at the final inspection. All warranties and guarantees shall be made out to the Mississippi Department of Transportation.

SECTION 721 - MATERIALS FOR SIGNING

721.01--General. All materials included in this section will be conditionally accepted on the basis of the manufacturer's certification of compliance, as specified in Subsection 106.04, except those materials normally tested by the Department; i.e. concrete, reinforcing steel, timber posts, etc.. The State Materials Engineer shall be furnished the original and three copies of the manufacturer's certification. The Department reserves the right to test or have tested by a commercial laboratory any material that has been conditionally accepted by certification.

721.02--Ferrous Materials.

721.02.1--General. All welds shall be mechanically cleaned before galvanizing. All ferrous metal except reinforcing steel, and sheet steel unless otherwise specified, shall be zinc-coated, galvanized, by the hot dip method in accordance with AASHTO Designation: M 111 after all fabrication has been completed.

721.02.2--Structural Steel for Sign Supports. Structural steel used in sign support structures shall be of standard shape. Structural steel pipe per ASTM

Designation: A 53 shall be manufactured by the open-hearth or basic oxygen process.

721.02.2.1--Ground Mounted Sign Supports. Posts shall be provided with "break-away" mountings as shown on the plans using the following materials:

Structural steel beams for posts per AASHTO Designation: M 160.

Steel plates for steel beam posts per AASHTO Designation: M 160.

Welded and seamless steel pipe for posts per ASTM Designation: A 53, Type E or S, Grade B, or steel structural tubing per ASTM Designation: A 501.

U-Section posts for supplementary directional signs per Subsection 721.02.3 "Steel Posts for Small Signs" modified as shown on the plans.

Structural steel shapes, bars, and plates used for bracing, framing and other accessories, including base plates for steel posts, per ASTM Designation: A 36.

High strength bolts, nuts, and washers for post bases and for fuse plates per Subsections 717.01.7 and 810.02.21 modified as shown on the plans.

721.02.2.2--Overhead Sign Supports. Materials approved for use in the construction of overhead sign supports include the following:

Welded and seamless steel pipe per ASTM Designation: A 53, Type E or S, Grade B or Type F.

Steel structural tubing per ASTM Designation: A 501.

Structural shapes, plates, and bars per ASTM Designation: A 36.

Castings for post base and truss flange per AASHTO Designation: M 106, Grade 35018.

Castings for post caps and chord caps per AASHTO Designation: M 105, Class 25 S.

High strength bolts, nuts, and washers for chord connections per Subsections 717.01.7 and 810.02.21.

Anchor bolts per ASTM Designation: A 307, Grade A.

721.02.3--Steel Posts for Small Signs.

721.02.3.1--Material. The posts shall be of high carbon rail steel ASTM Designation: A 499.

721.02.3.2--Workmanship. All posts shall be straight with no bending, warping, splits, or breaks.

721.02.3.3--Cross-Section. The posts shall be "U" section as shown on the plans. The bends in the cross-section of the post must be sharp and well defined, and the radius of the bend shall not be greater than 13/32 of an inch.

721.02.3.4--Weight. The weight of the posts per linear foot without ground plates, shall be 2.0 pounds for seven-foot and nine-foot lengths and 3.0 pounds for eleven-foot and fourteen-foot lengths with a tolerance of three and one-half percent, or as shown on the plans.

721.02.3.5--Punching. The posts shall be punched on the center line of the web while hot. Posts of 7-foot to 14-foot lengths shall have 3/8-inch holes one inch apart on centers starting one inch from the top of the posts and extending the full length of the post.

721.02.3.6--Pointing. The posts shall not be pointed.

721.02.4--Reinforcing Steel. Reinforcing steel used shall conform to Section 711 and shall be placed in accordance with Section 602.

721.02.5--Bolts, Nuts, Washers, Screws, and other Hardware. Except as otherwise specified, all bolts, nuts, washers, sheet metal screws, and machine screws shall be coated by the zinc chromate process. The zinc chromate process shall be in accordance with the requirements of ASTM Designation: B633. Bolts shall have a 1/2-inch head and shall meet the requirements of ASTM Designation: A307, Grade A. Nuts shall be self-locking and shall meet the requirements of ASTM Designation: A563. Flat washers shall be installed between the sign support and the self-locking nut and shall meet the requirements of ANSI Designation: B27.2. Sheet metal screws shall meet the requirements of ANSI Designation: B18.6.4. Machine screws shall meet the requirements of ANSI Designation: B18.6.3. Vinyl spacers shall be installed between the bolt head and the sign face and shall meet the following maximum dimensions: 7/8-inch outside diameter by 3/8-inch inside diameter by 1/16-inch thickness.

Post clips used with extruded panel signs shall be cast aluminum per ASTM Designation: B 108, Alloy No. 356.0-T6 or extruded aluminum per ASTM Designation: B 221, Alloy 6063-T6. Unless otherwise specified, all bolts, sheet metal screws, and machine screws used in assembling signs, frames, and post braces, including post clips and panel bolts, shall be in accordance with ASTM Designation: A 307, Grade A.

721.03--Aluminum. All aluminum shall be free from corrosion, white rust, water stains, dirt, and grease. Fabrication shall be accomplished in a uniform and workmanlike manner. All fabrication, including cutting and punching of holes, shall be completed prior to metal treatment. Sign blanks shall be cut to size and shape and shall be free of buckles, warps, dents, cockles, burrs, and defects resulting from fabrication. The surface of all sign blanks shall be flat.

All blanks not having corner radii shall have square 90° corners to facilitate sign fabrication.

All blanks requiring holes shall have “MDOT” debossed on the blank in a location so as not to be covered by the post when erected. The debossed letters shall be not less than 3/8 inch high and shall be approximately 0.006 inch deep so as not to be visible on the other side of the blank.

721.03.1--Sheet Aluminum. Sheet aluminum or blanks shall meet the requirements of ASTM Designation: B 209, Alloy 6061-T6 or 5052-H38. Gauge, dimension, punching and corner radii shall be in accordance with the plans.

721.03.2--Extruded Signs. Extruded sign panels, extruded moldings, and extruded post clips shall meet the requirements of ASTM Designation: B 221, Alloy 6063-T6. Sections and dimensions shall be as shown on the plans. The panel shall be of the butt type, designed to withstand a wind pressure of 50 pounds per square foot. All panels shall be flat and straight within commercial tolerances as established by the aluminum industry. Extruded sign sections shall be subject to approval by the Engineer. Extruded sign sections shall be provided with slotted bolt holes. Sign moldings and post clips shall be designed for the sign panel section with which it is used. Sign moldings shall be anchored to the sign panels by means of aluminum pull-through rivets or self-tapping screws.

721.03.3--Overhead Sign Support Material. Material approved for use in the construction of Overhead Sign Supports include the following:

Extruded structural tube and pipe per ASTM Designation: B 221, B 241 or B 429, Alloy 6061-T6.

Extruded structural tube and pipe per ASTM Designation: B 221, B 241 or B 429, Alloy 6063-T6.

Structural shapes per ASTM Designation: B 308, Alloy 6061-T6.

Sheet and plate per ASTM Designation: B 209, Alloy 6061-T6.

Castings for post and chord caps per ASTM Designation: B 26, Alloy No. 356.0.

Base and filler metals for welding shall be as listed below:

<u>Base</u>	<u>Filler</u>
<u>Metal Alloys</u>	<u>Metal Alloys</u>
6061-T6 to 6061-T6	ER-5556
6063-T6 to 6061-T6	ER-4043, ER-5356
or 6063-T6	or ER-5556

721.04--Concrete. Unless otherwise specified, concrete shall be Class B. Composition, manufacture, and placement shall be in accordance with Section 601.

721.05--Colors and Paint. All colors for signs shall match FHWA specifications for standard highway sign colors.

The molding which is attached to the extruded panel signs shall be painted with a semi-gloss baking enamel meeting Federal Specification TT-E-529a.

Aluminum paint shall conform to Subsection 710.02.1.

Transparent and black opaque process colors used in silk screening shall be that or equal to that recommended by the manufacturer of the retroreflective sheeting, and shall match FHWA Specifications for standard highway sign colors. Toning of certain colors for adjustment in hue shall be accomplished in accordance with the recommendations of the manufacturer of the process paste.

721.06--Reflective Sheeting.

721.06.1--General. Retroreflective sheeting materials shall comply with all applicable requirements of ASTM Designation: D 4956, except as specifically modified herein, and be listed on the Department's "Approved Sources of Materials".

Reflective sheeting shall be one of the following types.

Type III. A high-intensity retroreflective sheeting. This shall be an encapsulated glass-bead or unmetallized microprismatic retroreflective material. This sheeting shall have a protected, pre-coated, pressure-sensitive adhesive backing.

Type VII. A super high-intensity retroreflective sheeting. This shall be an unmetallized microprismatic retroreflective material. This sheeting shall have a protected, pre-coated, pressure sensitive adhesive backing.

Type VIII. A super high-intensity retroreflective sheeting. This shall be an unmetallized microprismatic retroreflective material. This sheeting shall have a protected, pre-coated, pressure sensitive adhesive backing.

Type IX. A very-high intensity retroreflective sheeting. This shall be an unmetallized, microprismatic retroreflective material. This sheeting shall have a protected, pre-coated, pressure sensitive, adhesive backing.

All other retroreflective sheeting shall be as shown in the plans.

721.06.2--Performance Requirements. The retroreflective sheeting shall have the following minimum brightness values at 0.2° and 0.5° observation angle, in addition 1.0° for Type IX sheeting, expressed as average candelas per footcandle per square foot of material.

Sheetings and inks processed and applied in accordance with the manufacturer’s recommendations, shall perform effectively for the number of years stated below. The sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that: (1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions or (2) the coefficient of retroreflection is less than the minimum specified for that sheeting during the periods listed below. For screen printed transparent colored areas on white sheeting, the coefficients of retroreflection shall not be less than 70% of the values for the corresponding color in the table.

Type III Sheeting Retain 85% of initial values listed in Table 1 through 7 years
Retain 80% of initial values listed in Table 1 between 7 & 10 years

Type VII Sheeting Retain 85% of initial values listed in Table 2 through 7 years
Retain 80% of initial values listed in Table 2 between 7 & 10 years
Retain 50% of initial values listed in Table 2 through 3 years for Fluorescent Orange

Type VIII Sheeting Retain 85% of initial values listed in Table3 through 7 years
Retain 80% of initial values listed in Table 3 between 7 & 10 years
Retain 50% of initial values listed in Table 3 through 3 years for Fluorescent Orange
Retain 80% of initial values listed in Table 3 through 7 years for Fluorescent Yellow/Green & Fluorescent Yellow

<u>Type IX Sheeting</u>	Retain 85% of initial values listed in Table 4 through 7 years Retain 80% of initial values listed in Table 4 between 7 & 10 years Retain 80% of initial values listed in Table 4 for 7 years for Fluorescent Yellow/Green & Fluorescent Yellow
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MINIMUM COEFFICIENTS OF RETROREFLECTION

Candela per foot candle per square foot (cd/ft/ft²)

Per ASTM Designation: E 810

TABLE 1
Type III Sheeting

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown
0.2°	-4°	250	170	100	45	45	20	12
0.2°	+30°	150	100	60	25	25	11	8.5
0.5°	-4°	95	62	30	15	15	7.5	5.0
0.5°	+30°	65	45	25	10	10	5.0	3.5

TABLE 2
Type VII Sheeting

Observation Angle	Entrance Angle	White	Yellow	Green	Red	Blue	Brown	Fluorescent Orange
0.2°	-4°	750	560	75	150	34	23	200
0.2°	+30°	430	320	43	86	20	10	85
0.5°	-4°	240	180	24	48	11	8	90
0.5°	+30°	135	100	14	27	6.0	4	50

MINIMUM COEFFICIENTS OF RETROREFLECTION

Candela per foot candle per square foot (cd/ft/ft²)

Per ASTM Designation: E 810

TABLE 3
Type VIII Sheeting

Observation Angle	Entrance Angle	White	Yellow	Green	Red	Blue	Brown	Fluorescent Orange	Fluorescent Yellow/ Green	Fluorescent Yellow
0.2°	-4°	700	525	70	105	42	21	200	480	375
0.2°	+30°	325	245	33	49	20	10	85	240	170
0.5°	-4°	250	190	25	38	15	7.5	90	235	165
0.5°	+30°	115	86	12	17	7	3.5	50	110	85

TABLE 4
Type IX Sheeting

Observation Angle	Entrance Angle	White	Yellow	Green	Red	Blue	Fluorescent Yellow / Green	Fluorescent Yellow
0.2°	-4.0°	380	285	38	76	17	325	240
0.2°	+30.0°	215	162	22	43	10	205	150
0.5°	-4.0°	240	180	24	48	11	240	165
0.5°	+30.0°	135	100	14	27	6.0	110	75
1.0°	-4.0°	80	60	8	16	3.6	65	45
1.0°	+30.0°	45	34	4.5	9	2.0	35	25

721.06.3--Certification. The Contractor shall require the supplier to furnish certified evidence and/or samples to the Engineer showing conformance to these requirements. Manufacturer's warranties or guarantees provided as customary trade practice shall be furnished the Department.

721.06.4--Color. Reflective sheeting shall meet the color requirements of ASTM Designation: D 4956. See Table 5 below for color specifications for fluorescent yellow green, fluorescent orange, and fluorescent yellow sheeting.

TABLE 5
Color Specification Limits for New Sheeting - Daytime

Color	Chromaticity Coordinate 1	Chromaticity Coordinate 2	Chromaticity Coordinate 3	Chromaticity Coordinate 4	Total Luminance Factor Limit Y _T Min.
	x y	x y	x y	x y	
Fluorescent Yellow Green	0.387 0.610	0.460 0.540	0.438 0.508	0.376 0.568	60%
Fluorescent Orange	0.562 0.350	0.645 0.355	0.570 0.429	0.506 0.404	30%
Fluorescent Yellow	0.521 0.424	0.557 0.442	0.479 0.520	0.454 0.491	40%

721.06.5--Adhesive. The retroreflective sheeting shall include a pre-coated pressure sensitive adhesive, as referenced in ASTM Designation: D 4956, Class I, applied without the necessity of additional adhesive coats on the retroreflective sheeting or application surface.

The Class I adhesive shall be a pressure sensitive adhesive of the aggressive tack type requiring no heat solvent or other preparation for adhesion to smooth clean surfaces.

The protective liner attached to the adhesive shall be removed by peeling without soaking in water or other solutions and shall be easily removed after accelerated storage for four hours at 160°F under a weight of 2.5 pounds per square inch.

721.06.6--Additional Contract Requirements. This Subsection is applicable only when the sheeting material is being purchased for use in the MDOT Sign Shop. In addition to the above requirements, the following requirements must also be met.

721.06.6.1--Sheeting Manufacturer’s Replacement Obligation. Where it can be shown that retroreflective traffic signs with Type III, Type VII, Type VIII, or Type IX sheeting supplied and used according to the sheeting manufacturer’s recommendations have not met the performance requirements, the sheeting manufacturer shall replace the sheeting required to restore the sign surface to its original effectiveness during the entire 10 years. In addition, during the first seven (7) years the manufacturer of Type III, Type VII, Type VIII, or Type IX sheeting shall cover the cost of restoring the sign surface to its original effectiveness at no cost to the Department for materials and labor for both sign

manufacture and installation.

721.06.6.2--Technical Assistance Requirements.

Instruction and Training. The manufacturer supplying the retroreflective sheeting shall provide at no additional cost the services of a qualified technician for instruction and training at the sign manufacturing facility. This instruction shall be provided bi-annually or when requested, and shall include but not be limited to training films, material application, equipment operation, silk screening techniques, packaging, storage, and other proven sign shop practices as they apply to the retroreflective sheeting supplied by the manufacturer, and to assure that the resulting signs can comply with the applicable specifications.

Technical Service. The sheeting manufacturer shall, without additional cost to the Department, provide the sign shop with competent technical service and product information including service on screen printing problems with the inks furnished by the manufacturer.

Equipment. The manufacturer supplying the retroreflective sheeting shall provide technical assistance for the recommended sheeting application equipment and certify that trained personnel shall be available on 72 hours notice to render such service necessary to adjust ink consistency or otherwise modify the application of silk screen equipment to accommodate use of manufacturer's sheeting. "Service" is understood to mean the capability of calibration and trouble shooting, as well as the training and retaining of personnel as required.

721.06.6.3--Warranty. Any warranties prepared by the manufacturer shall be included with the bid documents.

721.07--Delineators. Delineators shall consist of encapsulated lens reflective sheeting of the specified colors applied to sheet metal with mechanical equipment in a manner specified by the sheeting manufacturer. The sheet metal shall be the same as that used for small sheet signs as required under Subsection 721.03.1.

721.07.1--Flexible Posts. Flexible posts for delineators shall be composed of high impact fiberglass reinforced composite, engineering blended plastic or thermosetting polymers which is reasonably unaffected by long term U.V. exposure.

Flexible posts for delineators must be one from the Department's "Approved Sources of Materials". Prior to use, the Contractor shall furnish the Engineer three copies of the manufacturer's certification for each shipment stating that the material furnished is of the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

721.07.1.1--Performance Testing for Flexible Posts.

721.07.1.1.1--Impact Resistance. The post must be self erecting after withstanding 10 vehicle impacts at temperatures of 0°F or above without complete loss of serviceability. The impacts shall be made at an impact angle of $25 \pm 5^\circ$ with a sedan at 35 mph.

721.07.1.1.2--Heat Resistance. A post shall be conditioned a minimum of two hours in an oven at $115^\circ \pm 3^\circ\text{F}$. The conditioned post shall be capable of straightening itself within 10 seconds when bent 90° at or near midpoint for each of four bends. The test on each post shall be completed within two minutes after removal from the oven. The post shall be bent in the direction to form a 90° angle on the convex side of the post.

721.07.1.1.3--Cold Resistance. A post shall be conditioned a minimum of two hours at $-5^\circ \pm 3^\circ\text{F}$ in an environmentally controlled test chamber. Testing shall be performed in the environmental chamber. The conditioned post shall not be adversely effected when bent at or near midpoint to a 90° angle formed on the convex side of the post. The post shall return to its original shape within 60 seconds for each of four separate bends.

721.07.1.1.4--Color Fastness. The post materials shall be exposed for 1000 hours in an Atlas Type B or BH Xenon Arc Weatherometer per ASTM Designation: G 26 with no significant yellowing or darkening.

721.07.1.2--Acceptance Procedure. Flexible posts for delineators must be one from the Department's "Approved Sources of Materials". Prior to use, the Contractor shall furnish the Engineer three copies of the manufacturer's certification for each shipment stating that the material furnished is of the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

721.08--Removable Copy. Removable copy shall include letters, numerals, symbols, and borders. The designs for the capital and lower case alphabets shall conform to that recommended by the Federal Highway Administration. The initial letters and numerals will be Series E modified or as specified on the plans. All removable copy will be attached to the sign face from the front by means of a huck or a cherry rivet gun and aluminum pull-through rivets without the use of clips. Removable copy shall consist of encapsulated lens silver retroreflective sheeting which has been carefully selected by the manufacturer for uniformity of day and night appearance and applied to flat aluminum backing. The backing shall be a minimum of .032" thick aluminum sheet as per ASTM Designation: B 209, alloy 3003-H14. The metal treatment shall be the same as that for aluminum sheet.

721.09--Timber Sign Posts. The posts shall conform to the requirements set forth in Subsection 712.05.1.3, except that the preservative shall conform with Subsections 718.04.3 or 718.04.4.

721.10--Direct Applied Copy. Direct applied copy which is to be provided on guide directional signs, ground mounted or overhead , shall be directly applied to the sign face. Direct applied copy shall include letters, numerals, symbols and borders. The designs for capital and lower case shall be as required by the plans. All type of copy other than caps and lower case shall be as required by the plans. All type faces/fonts shall conform to the recommendations contained in standards published by the Federal Highway Administration. All direct applied copy shall be attached to the sign face by means of pressure sensitive adhesive meeting the requirements of Subsection 721.06.5--Adhesive. Direct applied copy shall consist of encapsulated lens silver retroreflective sheeting meeting the requirements of Subsection 721.06--Reflective Sheeting.

All signs shall be delivered to the site of their erection in one piece with all bolts, rivets, moldings, extrusions, copy, and other required appurtenances thereto attached, complete and ready to be mounted to the sign support structure. Any required supplemental or temporary supports required for stability during transport shall be firmly attached but easily removed prior to erection.

SECTION 722 - MATERIALS FOR TRAFFIC SIGNAL INSTALLATION

722.01--General. Acceptance of all material in this Section is subject to Subsections 106.01 and 106.04 entitled "Source of Supply and Quality Requirements" and "Certification of Compliance", respectively.

722.02--Poles. The various pole types are as follows: Type I-Strain, Type II-Single Mast Arm, Type III-Double Mast Arm, Type IV-Strain and Mast Arm Combination, Type V-Pedestal Pole for Traffic Signal, Type VI-Pedestal Pole for Pedestrian Signal, Type VII-Pedestal Pole for Detector Equipment Cabinet. Determination of required sizes, lengths, and gauges of Type I, II, III, and IV steel poles shall be the responsibility of the Contractor in accordance with the plans and Specifications.

Type I, II, III and IV poles shall be steel meeting the requirements of Subsection 722.02. Type V, VI, and VII poles shall meet the requirements of Subsection 722.15.

722.02.1--General. These specifications are for aluminum, steel, concrete and wood poles for use as signal equipment supports, and other support structure as required.

722.02.1.1--Taper. All poles shall have a constant taper from bottom to top and may be round or polyhedral.

722.02.1.2--Type Mountings. The type mounting shall be either aluminum, steel, concrete, or wood as indicated on the plans.

Aluminum, steel, or concrete shall have either precast butts for direct mounting in the earth or attached base mounts for mounting on concrete foundations or on break-away bases.

Wood poles shall be mounted directly in the earth.

722.02.1.3--Design Strength Requirements. The design strength requirements for the support structure shall be in accordance with the AASHTO design specification, the plans, and for the wind load as indicated on the plans. The support structure shall consist of the pole, anchor bolts, base plate, mast arm, and other supporting devices.

722.02.1.4--Design Calculations and Data or Manufacturer's Certifications. The Contractor shall submit for approval by the Engineer, five copies of the information listed below to certify that the support structure is designed to meet the above requirements.

722.02.1.4.1--The Manufacturer's Certification.

722.02.1.4.2--Design Calculations and Data.

- (a) Complete detailed drawings identifying and describing each member of the support structure and the guaranteed minimum yield and ultimate strengths.
- (b) Specifications for fabrications and erections of the structure.
- (c) Complete design calculations.
- (d) Where design procedure is derived from computer programs, computer read-outs may be submitted in lieu of design calculations required above provided a detailed example of a typical problem showing the necessary calculations performed is included along with the computer read-outs.

722.02.1.5--Handhole. All steel and aluminum poles not mounted on breakaway transfer bases shall have a minimum of four by six inch reinforced handhole. A grounding nut that will accommodate a one-half inch, 13 UNC threaded bolt or stud shall be installed inside the pole.

722.02.2--Aluminum Poles-Conventional.

722.02.2.1--Poles. The poles shall be spun or formed from aluminum seamless tubing meeting requirements of ASTM Designation: B 210, Alloy 6063-T4 and after fabrication shall have mechanical properties not less than those specified for Alloy 6063-T6. The poles may also be formed from aluminum plates or sheets meeting the requirements of ASTM Designation: B 209, Alloys 5052-H34 or

5086-H34.

722.02.2.2--Castings. Castings shall be in accordance with ASTM Designation: B 108 or B 26 Structural Alloy, ANSI 356.0 UNS A03560-T6, Non-Structural Alloy, ANSI B443.0 UNS A24430. The structural, one-piece base castings shall be provided with four slotted holes to receive the anchor bolts, and tapped holes for attaching the removable cover. The base shall telescope and be affixed to the lower end of the shaft with two continuous welds made by the metallic-arc-consumable electrode-inert gas-shielded process, one inside of the base at the end of the shaft, the other outside the top of the base.

722.02.2.3--Covers and Caps. Approved removable bolt covers shall be provided and attached to the upright portion of the base by means of stainless steel hex head screws. Shaft and mast arm caps shall be fastened with stainless steel hex head screws.

722.02.2.4--Finish. External surface of shafts shall have a satin-type finish, clean and smooth, with all details defined and true to pattern.

722.02.3--Steel Poles-Conventional.

722.02.3.1--Poles. The poles shall be formed from commercial quality carbon steel with a yield strength of 55,000 psi, ASTM Designation: A 595, for round poles; and a yield strength of 50,000 psi, ASTM Designation: A 1011, for multi-sided poles.

The shaft shall be galvanized in accordance with the requirements of ASTM Designation: A 123.

The shaft shall have a taper from 0.10 to 0.14 inch per foot.

722.02.3.2--Base Plate. The poles shall be equipped with either a structural quality hot rolled carbon steel plate with a minimum yield strength of 36,000 psi, ASTM Designation: A36, or low alloy steel plate with a minimum yield strength of 42,000 psi, ASTM Designation: A572. The base plate shall telescope the shaft and affix to the shaft with two continuous electric arc welds; one on the inside of the base plate at the end of the shaft, the other on the outside at the top of the base plate. The base plate shall be galvanized in accordance with ASTM Designation: A 123.

722.02.3.3--Covers and Caps. Approved removable bolt covers and caps shall be provided and attached to the shaft with self-threading stainless steel hex head screws.

722.02.4--Concrete Poles.

722.02.4.1--General. Concrete poles shall be precast, machine made in steel forms by the centrifugal process to produce dense concrete members of the dimensions and design shown on the plans, and in accordance with these specifications. The shaft shall be tapered, octagonal or circular in cross section with a smooth outer finish.

722.02.4.2--Aggregate. All aggregate shall be graded from 3/8 inch to No. 100 sieve, with not more than 10 percent passing the No. 100 sieve. Characteristics of aggregates, other than gradation, shall comply with the requirements of Section 703.

722.02.4.3--Cement. Portland Cement used in the manufacture of poles shall conform to the requirements of Section 701.

722.02.4.4--Water-Cement Ratio. Water used shall conform to the requirements of Subsection 714.01.2. The water-cement ratio shall be in the proportion required to produce concrete with a minimum compressive strength of 3,500 psi, in 24 hours after curing. Test data shall be furnished to the Engineer, when requested.

722.02.4.5--Reinforcement. Either prestressed or conventional reinforcement meeting the requirements of Sections 602, 711 and 804 may be used. Prestressed poles shall be reinforced with high tensile prestressing steel having an ultimate strength of at least 240,000 psi, prestressed to at least 60 percent and not more than 70 percent of ultimate strength. When additional reinforcing is used to meet special requirements it shall be of intermediate grade steel. Conventionally reinforced poles shall contain deformed bars having an ultimate tensile strength of 145,000 psi. Wire for the spiral wind shall have a minimum diameter of 87/1000 inch with 260,000 psi. Reinforcing bars shall be assembled in a cage with rods evenly spaced from one another with attached concrete spacers to insure a minimum concrete cover of 9/16 inch. The spiral wind shall be one continuous wire wrapped around the cage with maximum spacing of 1½ inches between spirals.

722.02.4.6--Method of Manufacture. Poles shall be cast in metal forms true to design, including integral butts when specified.

Concrete shall be mixed not less than five minutes, and shall be placed in one continuous operation. When filled, the mold shall be rotated at high speed to insure a dense concrete by centrifugal force and provide a cable raceway of not less than 1 3/4 inch in diameter, extending throughout the length of the pole. The finished poles shall have smooth surfaces.

Following the casting operation the concrete shall be cured with low temperature steam.

722.02.4.7--Precast Butt. When specified on plans, an integral butt foundation shall be cast with the pole in the spinning process. When so cast, the pole shall be provided with a minimum of 2½-inch by 6-inch handhole with approved cover, located 18 inches above ground line. A minimum of 9-inch by 2½-inch cable entrance shall be provided 18 inches below ground line.

722.02.5--Wood Poles. The wood poles shall meet the requirements of the latest edition of ANSI-05.1, "American National Standard for Wood Poles - Specifications and Dimensions", for Southern pine poles having a fiber stress of 8,000 psi. The dimensions of the poles shall be as specified in the table below. The poles shall be inspected and treated in accordance with Section 718.

DIMENSIONS OF SOUTHERN PINE POLES

Class		1	2	3	4	5	6	7	9	10
Minimum Circumference at top, Inches		27	25	23	21	19	17	15	15	12
Length of Pole, Feet	Groundline* Distance from Butt, Feet	Minimum Circumference at Six Feet from Butt, Inches								
20	4	31.0	29.0	27.0	25.0	23.0	21.0	19.5	17.5	14.0
25	5	33.5	31.5	29.5	27.5	25.5	23.0	21.5	19.5	15.0
30	5.5	36.5	34.0	32.0	29.5	27.5	25.0	23.5	20.5	
35	6	39.0	36.5	34.0	31.5	29.0	27.0	25.0		
40	6	41.0	38.5	36.0	33.5	31.0	28.5			
45	6.5	43.0	40.5	37.5	35.0	32.5	30.0			
50	7	45.0	42.0	39.0	36.5	34.0				
55	7.5	46.5	43.5	40.5	38.0					
60	8	48.0	45.0	42.0	39.0					
65	8.5	49.5	46.5	43.5	40.5					
70	9	51.0	48.0	45.0	41.5					
75	9.5	52.5	49.0	46.0						
80	10	54.0	50.5	47.0						
85	10.5	55.0	51.5	48.0						
90	11	56.0	53.0	49.0						
95	11	57.0	54.0							
100	11	58.5	55.0							
105	12	59.5	56.0							
110	12	60.5	57.0							
115	12	61.5	58.0							
120	12	62.5	59.0							
125	12	63.5	59.5							

* The figures in this column are intended for use only when a definition of groundline is necessary in order to apply requirements relating to scars, straightness, etc.

722.03--Electric Cable. The cable shall be high-grade insulated conductors of first class material and workmanship manufactured in accordance with the best engineering practices, suitable for use in trays, ducts, conduit, aerial direct burial application. It shall be accessible to Department representatives for inspection at all reasonable times. In lieu of such inspection, the Department may require that three certified copies of factory tests be furnished.

The materials used for electrical conductors, insulation, jacket armoring and covering shall meet the requirements as indicated on the plans and these requirements.

Cable shall be of the following types with number of conductors and conductor size as indicated on the plans.

Signal Cable. Polyethylene insulated, polyethylene jacketed cable rated at 600 volts meeting the requirements of IMSA Specification No. 20-1, 1984, and with integral messenger cable meeting the requirements of IMSA Specification No. 20-3, 1984.

Power Cable. High density polyethylene covered drawn copper line wire meeting the requirements of IMSA Specification No. 26-3, 1973.

Communication Cable. Paired polyethylene insulated, polyethylene jacket cable with electrical shielding rated at 300 volts meeting the requirements of IMSA Specification No. 40-2, 1984, with integral messenger cable meeting the requirements of IMSA Specification No. 40-4, 1984.

Loop Detector Lead-In Cable. Shielded cable conforming to IMSA Specification No. 50-2, 1984, for polyethylene insulated, polyethylene jacketed loop detector lead-in cable. Unless otherwise indicated, the cable shall be 2-conductor,, AWG # 14.

Loop Detector Wire. Cross-linked polyethylene insulated loop detector wire rated at 600 volts meeting the requirements of IMSA Specification No. 51-3, 1984.

Tracer Cable and Warning Tape. Tracer cable shall be Type THHN, annealed copper, insulated with high-heat and moisture resistant PVC, jacketed with abrasion, moisture, gasoline, and oil resistant nylon, or UL-listed equivalent. The cable shall be AWG# 10 with 19 strands and a 20-mil insulation thickness. It shall be suitable for operations at 600 volts as specified in the National Electrical Code. The warning tape shall be a non-detectable commercial warning tape approved by the Engineer.

722.04--Messenger Cable. Messenger cable for aerial support of electric cable, traffic signal conduit, traffic signal devices, etc. shall conform to the

requirements of ASTM Designation: A 475 for 3/8 inch seven-strand utilities grade with Class "B" zinc coating. Brackets and/or other devices for aerial support shall be in accordance with details shown on the plans or approved by the Engineer.

Tether cable shall conform to the requirements of ASTM Designation: A 475 for 1/4-inch, 7-strand Siemens-Martin grade with Class "B" zinc coating.

722.05--Traffic Signal Conduit.

722.05.1--General. The traffic conduit shall be of the following types and indicated in the plans.

722.05.2--Type I Rigid Galvanized Steel. Rigid galvanized steel meeting the requirements of American Standards Association (ASA) Specifications C 80.1.

722.05.3--Type II Rigid Copper Nickel, Steel Alloy, Hot Dip Galvanized. Rigid copper nickel, steel alloy, hot dip galvanized containing 1.6 to 2.2 percent nickel and zero point 0.75 to 1.25 percent copper conforming to American Standard Association (ASA) Specification C 80.1 and Federal Specification WW-C-581.

722.05.4--Type III or Type IV Rigid Non-Metallic Conduit. Rigid non-metallic conduit shall be polyvinyl-chloride (PVC) meeting ASTM Designation: D 1785, as well as National Electric Manufacturers Association (NEMA) Publication TC-2.

722.05.5--Flexible Conduit. Flexible conduit shall be a smooth wall, high density polyethylene conduit designed to be used for cable. Unless otherwise approved by the Engineer, the conduit shall meet the requirements of ASTM Designations: D 2447, D 3035, D 3485, D 2239 and NEMA TC7.

722.05.6--Poly Vinyl Chloride (PVC) Coated Conduit. In addition to the above requirements for conduit, PVC coated conduit shall meet the requirements of UL 6 and NEMA RN1. The conduit shall be coated on the exterior by a 40-mil thick coating of PVC and on the interior by a 2-mil thick coating of urethane. All fittings for PVC coated conduit shall meet the requirements of UL 514B and NEMA RN1 and have the same coating type and thickness. Any component of the PVC conduit which has been scratched before or during the installation process shall be patched with a factory approved sealer.

722.05.7--Roll Pipe Conduit.

722.05.7.1--General. Roll pipe conduit, or duct, shall be manufactured from virgin high density polyethylene. The addition of clean rework material is permissible if generated in the manufacturer's own plant. The ducts shall be

supplied with either smooth, ribbed or corrugated walls and available in a multitude of colors. The duct shall be capable of being coiled or reeled in continuous lengths, transported, stored outdoors and subsequently uncoiled for installation without affecting its properties or performance.

722.05.7.2--Environmental Performance. The duct shall perform in underground and above-ground installations in an ambient temperature range of minus 30°F to 130°F without degradation of material properties. The duct specified for aerial installation shall be ultraviolet light-resistant. The duct shall be capable of being bent to a minimum supported radius of 10 diameters.

722.05.7.3--Workmanship. The duct shall be free of visible cracks, holes or other physical defects that would degrade its performance. It shall be as uniform as practicable in respect to overall dimensions, color, density, thickness, etc.

722.05.7.4--Color. The duct for exposed areas shall have a minimum of carbon black. All other colors shall have a UV light stabilizer which will protect the duct for a minimum of 12 months in direct sunlight.

722.05.7.5--Markings. The duct shall have a durable identification showing the name or trademark of the manufacturer, duct size, date and reference code; i.e., 2-inch IPS SCH-80. Duct for electrical cable should have "CAUTION – HIGH VOLTAGE" printed at regular intervals.

722.05.7.6--Capping. The open ends of each length of reeled duct shall be sealed by plastic caps to prevent the entrance of dirt and/or moisture.

722.05.7.7--Dimensions. The dimensions of the duct shall be as per ASTM Designation: D 3035. Wall thickness to be identified by either SDR, SIDR or SCH ratings. The manufacturer should advise the wall thickness required for a particular installation and/or conditions.

722.05.7.8--Pull Rope and Lubricant. The duct should be equipped with a factory installed rope or tape and prelubed to aid in the installation of cable. The rope can be provided with varying strengths as needed for a particular installation.

722.05.7.9--Couplings. Couplings should be available to quickly connect the duct and should be air and water-tight; i.e. Duct-Lok type couplings in either plastic or aluminum, depending on type of installation.

722.05.7.10--Packaging. The duct should be provided on lightweight metal reels in maximum lengths possible with no joints or splices. This will keep coupling requirements to a minimum. Special reel sizes and/or dimensions should be available for special installations.

722.05.7.11--Corrosion. The duct shall be resistant to most harsh chemicals and/or protected against degradation due to oxidation or general corrosion.

722.05.7.12--Installation. The duct shall be capable of being direct buried by plowing or trenching with no special consideration to using selective backfill. The duct shall also be capable of being encased in concrete pulled through a drilled hole.

722.05.7.13--Tests on Resins and Finished Duct. Lab tests on resins and finished products shall include, but are not limited to, the following:

ASTM Designation: D 3035, Polyethylene Plastic Pipe Based on Controlled Outside Diameter

ASTM Designation: D 1238, Flow Rates of Thermoplastics by Extrusion Plastometer

ASTM Designation: D 1505, Density of Plastics by the Density Gradient Technique

ASTM Designation: D 1693, Environmental Stress Crack Resistance (ESCR) of Polyethylene Pipe

ASTM Designation: D 1599, Short-Time Hydraulic Failure Pressure of Plastic Pipe

ASTM Designation: D 638, Tensile Properties of Plastics

ASTM Designation: D 2444, Impact Resistance of Plastic Pipe by Means of Tup.

ASTM Designation: D 2412, External Loading of Plastic Pipe

722.06--Pull Boxes. Pull boxes shall meet one of the following specifications:

- (a) Cast iron, ASTM Designation: A 48; Hot Dipped Galvanized, ASTM Designation: A 153
- (b) Precast, Class "B" concrete
- (c) Cast Aluminum, ASTM Designation: B 108, SG70-T6
- (d) Welded Aluminum, A1002-6061-T6
- (e) Composite

All pull boxes shall be in accordance with the detail drawings on the plans.

The boxes shall have a gasketed cover secured by set screws or bolts and shall be the type indicated on the plans meeting the following requirements.

Type 1 - Minimum Dimension: 8" x 8" x 6"

Type 2 - Minimum Dimension: 15" x 25" x 12"

Type 3 - Minimum Dimension: 16" x 12" x 12"

Type 4 - Minimum Dimension: 24" x 36" x 18"

Type 5 - Minimum Dimension: 30" x 48" x 18"

The words "Traffic Signal", "Traffic", "Signal", "Fiber Optics", etc. shall be inscribed on top of the covers as applicable.

722.07--Circuit Breakers. Circuit breakers shall be full magnetic with the required A.C. voltage rating and shall have sufficient capacity to interrupt the specified amps at different voltages. The "known" instantaneous trip point shall be no greater than ten times the rating in amperes. They shall be such that the instantaneous trip point and the continuous current rating are unaffected by change in the ambient temperature. Tripping and the time delay characteristics shall be actuated by changes of the magnetic flux. They shall have built-in flash protection to prevent damage due to high resistance faults and a quick break when tripping automatically. The operating handle shall be trip-free so that contact cannot be held closed against short circuit or abnormal over-load. Breakers shall indicate plainly the "ON" and "OFF" positions.

Each breaker shall be molded in a separate case and shall be independently removable from the enclosure for inspection and replacement.

722.08--Terminal Blocks. Each field wiring terminal block shall be of the heavy-duty pressure connector type with minimum rating of 35 amperes, 600 volts RMS, 60 Hz, and shall have a phenolic base, marking strip and corrosion resistant metal parts. Terminal screws shall be no smaller than size 10-32. Marking strips shall have permanent symbols including wire color as shown on the plans.

All working connections in the fixtures shall be terminated on molded, phenolic, barrier type, terminal blocks rated at 15 amperes, 600 volt, and shall have integral type white waterproof marking strips. All current carrying parts of the terminal blocks shall be insulated from the fixture with integral plugs or strips to provide an insulating value in excess of the line-to-ground flashover voltage. If the Contractor elects to use sectionalized terminal blocks, each section shall be provided with an integral barrier on each side and shall be capable of rigid mounting and alignment.

722.09--Grounding and Ground Rods. Ground rod shall be of copper-weld or an equivalent rust-resisting material of the length and diameter shown on the plans. Clamp for ground rod shall be of copper, bronze, or equivalent material. All ground wire shall be AWG No. 6 bare copper wire.

722.10--Expansion Joints. The expansion connection joint shall have an outer covering of flexible bronze or stainless steel wire braid over a flexible core of the same metal and an insulating liner. The end fitting shall be bronze or stainless steel. The expansion joint shall be UL listed.

722.11--Miscellaneous Hardware. All bolts other than those specified in Subsection 722.12, nuts, washers and other miscellaneous hardware shall be galvanized steel, stainless steel, or aluminum unless otherwise indicated on the plans. Galvanizing may be hot-dipped or by a mechanical method all in accordance with ASTM Designation: A 153 except for method of coating.

722.12--Anchor Bolts. The foundation anchor bolts shall have the strength requirements as specified in Subsections 722.02.1.3 and 722.02.1.4. Galvanizing conforming to ASTM Designation: A 153 shall be required for the full length of the threaded section plus an additional six inches of the foundation anchor bolts.

722.13--Detector Equipment Cabinets and Controller Cabinets. All cabinets shall be a NEMA Type 4 enclosure, based on NEMA standard No. 250-1985, "Enclosures for Electrical Equipment." Cabinets shall be fabricated from a minimum thickness of 0.125 inch aluminum alloy sheet meeting the requirements in ASTM Designation: B 209, for Alloy 5052, temper H32.

The cabinet shall have a minimum dimension of 20 inches high by 16 inches wide by 12 inches deep, and shall house without crowding 10 vehicle loop detectors, terminal blocks as required, circuit breaker, grounding studs, surge protection, and any other equipment necessary for a complete installation.

The cabinets shall have:

- 1) drilled and tapped bosses as required,
- 2) a screened breather at the top and at the bottom,
- 3) shelves or other suitable means of holding the equipment,
- 4) a solid grounding system by means of the pole ground system upon which the cabinet is mounted,
- 5) provisions for pole or pedestal mounting as required on the plans, and
- 6) a surge protection device for each detector amplifier to be housed in the cabinet.

The surge protection devices must be a three terminal device capable of protecting the detector against differential surges and common mode surges. It must be of the inductive type with a maximum DC resistance of 150 milliohms,

and an inductance of at least 4 millihenries. It must be capable of withstanding repeated 400 ampere surges. The device must be a two stage device capable of clamping a 250 ampere surge to 25 volts within 40 nanoseconds with the surge applied across the two detector leads. It must clamp a 250 ampere common mode surge to 35 volts.

722.14--Signal Heads.

722.14.1--Traffic Signal Heads - Conventional. Conventional traffic signal heads shall consist of all component materials necessary to form heads as specified on the plans and shall be complete with attachments for pole mounting, span wire mounting or mast arm mounting, as indicated, and for tie-ins to the feeder cable.

These signal heads shall meet the requirements of the latest ITE standards for Adjustable Face Vehicle Traffic Control Signal Heads, the National Electrical Code and the Manual on Uniform Traffic Control Devices where applicable.

No splicing of electric cables will be allowed exterior to the signal head. Quick disconnect hangers will be required where electric cables are too large to enter and leave the normal wire entrance fitting. However, in any signal installation, if one signal head requires quick disconnect hangers then all heads on that installation will be furnished with quick disconnect hangers.

722.14.1.1--Housing.

722.14.1.1.1--Materials. Each housing shall be made of one of the following materials:

- (a) Cast from aluminum alloy. Material for die cast housings shall be aluminum alloy S-12A, S-12B, SC-84A, SC-84B, or SG-100B, conforming to the specifications in ASTM Designation: B 85, or the latest revision thereof. Material for permanent mold castings shall be aluminum alloy S-5A or CS-72A conforming to the requirements of and as listed in ASTM Designation: B 108.
- (b) Fabricated from corrosion resistant U.V. stabilized polycarbonate resin material. The moldings shall be a minimum of 0.090 inches thick and be ribbed for additional strength at point of high stress. Additional thickness shall be provided as necessary to eliminate light transmission through the housing, door, visor, or back plate. The housing of each section shall be a one piece, corrosion resistant, molding with integral sides, top and bottom, free of voids, cracks, inclusions, or blow holes.

722.14.1.1.2--Features. Each housing shall be furnished with provisions for mounting of a back plate. The top and bottom of the housing shall have an

opening two inches in diameter to accommodate standard 1½-inch pipe, with no other opening in the top or bottom of the housing. Individual signal sections shall be fastened together, one above the other into a complete signal face, by means of plated nuts, bolts and washers in such a manner that any section may be rotated about a vertical axis and positioned at an angle with respect to any adjacent section. The opening hub shall have 72 circumferential serrations to secure each section in its orientation, adjustable in five degree increments, and prevent its inadvertent rotation. A minimum six-position labeled barrier terminal block shall be provided in each signal face for the purpose of field connections. The barrier terminal shall be installed in the circular yellow or yellow arrow section of each signal face. If the face has both of these sections, the terminal block shall be installed in the circular yellow section. There shall be provisions for the attachment of a 3/16 inch tether line to the bottom of each span wire mounted signal head. A pinnacle shall be provided to close all 1½-inch holes in each housing which will not otherwise be sealed from the weather when installed with the specified mounting hardware.

722.14.1.2--Door. Each door shall be made of a material that is one of the above materials and which is compatible with the material of the housing, except that doors for plastic housings shall be plastic. The outer face of the door shall have four holes equally spaced about the circumference of the lens opening to accommodate the secure mounting of the signal head tunnel visor. The visor shall fit flush against the door and no light shall leak between the door and the visor. Two stainless steel hinge pins shall attach the door to the housing, one in the upper left corner and one in the lower left corner of the door. Two stainless steel wing screws, one in the upper right corner and one in the lower right corner of the door, shall be used for opening the door and closing it tight against the housing. The wing screws shall be installed through the door with keepers to prevent their accidental removal or falling out. The removal of the hinge pins and the operation of the wing screws shall not require the use of tools.

722.14.1.3--Optical System. The optical system shall consist of a lens, reflector and lamp socket. The system shall be designed to minimize sun phantom and eliminate light spill over. Prefocused incandescent lamps shall be the light source for all signals. The signals shall be equipped with and designed for 69 watt - 130 volt lamps with 2 7/16" LCL in eight-inch signals and 150 watt - 130 volt lamps with 3" LCL in 12-inch signals that conform to the latest Institute of Transportation Engineers standard on traffic signal lamps. All vehicle signal lenses shall be polycarbonate resin or acrylic and shall conform to the latest standards of the Institute of Transportation Engineers and American Standards Association optical specification. All reflectors shall be of ALZAK aluminum construction. The lamp socket shall be of bakelite construction, gasketed and be easily removable from the rear of the reflector for lamp replacement without the use of tools or the removal of the lens or reflector. The socket shall be fixed focus and permit its rotation a full 360 to orient bulb filament openings. The socket shall be securely held in the reflector so as not to loosen, rotate, or fall out

under vibration of traffic and wind movement of the signal head. The lamp socket shall be provided with two coded No. 18 AWG copper wire leads. The leads shall be fitted with insulated spade wire terminals and be of sufficient length to make field connections at the barrier terminal block. The vehicular signal lens, signal lamp socket and reflector shall form a sealed module that is not broken when the door is opened. The seal shall prevent moisture, dust, and road film contamination from entering the optical module and the signal housing.

722.14.1.4--Visors. Each signal door shall be fitted with a tunnel visor. Eight-inch signals shall have visors a minimum of seven inches long, 12-inch signals shall have visors a minimum of nine and one half inches long. The visor shall be flat black inside and Federal Yellow outside. The visors shall be attached to the door at four equally spaced locations with four placed screws or four bayonet-type self-locking tabs integrally formed with the visor. Visors for polycarbonate signal heads shall be made of a corrosion resistant polycarbonate resin at least 0.100 inch thick. Visors for metal signal heads shall be made from 0.064 inch minimum thickness aluminum alloy sheet.

722.14.1.5--Back Plate. Each signal head assembly, so required, shall be equipped with a back plate with a minimum width of five inches with radius corners. Steel rivets shall be provided for mounting to the signal housing. The back plate shall consist of one piece fabricated from corrosion resistant, flat polycarbonate resin material at least 0.125 inch thick or 0.064 inch minimum thickness aluminum alloy sheet.

722.14.1.6--Lenses. Traffic signal lenses shall be circular, red, yellow, or green in color, and eight-inch or 12-inch nominal diameter, as shown on the plans. No legend shall be permitted. Arrow lenses shall be circular, 12 inches in diameter, green or yellow in color, and be opaque except for the arrow legend. The lenses shall conform to all the applicable sections of the latest edition of ITE's Standard on Adjustable Face Vehicular Traffic Control Signal Heads.

722.14.1.7--Mounting Hardware. Span wire suspension fitting with cable entrance shall be a one-piece malleable iron casting, minimum wall thickness of 3/16 inch, and free of flash and voids. The cable entrance shall have a plastic bushing with a minimum inside diameter of one and one-quarter inch. The suspension fitting shall provide six separate, clevis pin positions for balancing the signal assembly. The thickness of the solid casting in this suspension area shall be a minimum of 5/8 inch. A hex head threaded malleable iron lock nipple shall be provided for attaching the signal head to the bottom of the suspension fitting for one face signals or to the top bracket of multiface signal brackets.

The mounting hardware for each signal face shall include a nylon, serrated, 72-tooth lock ring with full locking pins and a circular neoprene gasket for weather sealing.

Span wire suspension clamp assembly, consisting of a galvanized, malleable iron span wire clevis saddle, 5/8-inch diameter plated steel clevis pin with cotter key, two one-half inch plated steel "U" bolts with nuts and washers, no "J" bolts are permitted, and a galvanized malleable iron cable locking bar, all fitted for 3/8-inch guy span. Galvanizing is to meet ASTM Designation: A 153.

Brackets shall consist of a malleable iron center outlet body, schedule 40 pipe, elbows, serrated fittings, and other hardware as required to provide a multiface signal head assembly with internal wiring raceways to each face as specified.

Mounting brackets for mast arms shall conform to Subsection 722.11.

722.14.1.8--Color, Finish and Painting. Polycarbonate resin hardware shall have color impregnated throughout the material. The finish shall be smooth and unflawed. All metal hardware, except those specified as galvanized, plated, or stainless steel shall be painted with a primer coat and a finish coat of the best quality oven baked enamel. Lenses, reflectors, gaskets and polycarbonate parts shall not be painted. Signal head parts shall be colored as follows: Vehicle Head: Housing - federal yellow; Door - federal yellow; Tunnel Visor - flat black inside and yellow outside; Back Plate - flat black front and back; and Pole Bracket - federal yellow.

722.14.2-Traffic Signal Heads - Optically Programmed. Optically programmed traffic signal heads shall, in addition to the requirements prescribed in Subsection 722.14.1 above for conventional type, be so constructed, programmed, and operable, as to limit the visibility of the indication exclusively to the area where it is desirable that the indication be seen. This is to be accomplished with a built-in High Resolution Optical System designed for the purpose and is not to be accomplished by an arrangement of hoods, louver, or other external means.

722.14.3--Pedestrian Signal Heads - Conventional. Conventional pedestrian signal heads shall consist of all component materials necessary to form heads as specified on the plans and shall be complete with attachments for pole or post mounting. Heads shall conform to the applicable parts of the MUTCD.

Single section pedestrian heads shall be constructed of die cast aluminum. The housing shall be painted Federal Yellow. The housing and door shall be designed such that when properly assembled, they shall provide a waterproof and dustproof enclosure. All screws, bolts, hinge pins and other necessary fasteners shall be stainless steel.

An "egg crate" or "Z" crate type visor constructed of .030" minimum thickness, 100% impregnated black polycarbonate strips shall be provided with the signal head. The visor assembly shall be at least 1 1/2 inches deep and shall be bordered by a .040" minimum aluminum frame.

The design, manufacture and testing of lenses shall conform to the parts concerning "Traffic Signal Lenses" as set forth in "A Standard for Adjustable Face Traffic Control Signal Heads" as published by the Institute of Transportation Engineers. Individual letters of the legend shall be 4 1/2 inches high.

The reflector shall be a one piece reflector made of high temperature non-ferrous material or die-cast aluminum. The reflector shall consist of two parabolic curves, one behind the DON'T WALK legend and one behind the WALK legend. Construction shall be suitable to prevent any light from "leaking" from one legend to the other. Lamp sockets shall be designed to accommodate an A21, 67 watt lamp. Each socket shall be wired completely internally and ready for connection of field wiring. There shall be a minimum three position terminal block attached to the inside of the housing.

Prior to assembly, the housing and door frame shall be painted with one coat of primer and two coats of enamel. Color shall be Federal Yellow.

722.14.4--Pedestrian Signal Heads - Optically Programmed. Optically programmed pedestrian signal heads shall, in addition to the requirements prescribed in Subsection 722.14.3 above for conventional, be so constructed, programmed, and operable as to limit the visibility of the indication exclusively to the area where it is desirable that the indication be seen.

This is to be accomplished with a built-in High Resolution Optical System designed for the purpose and is not be accomplished by an arrangement of hoods, louvers or other external means.

722.14.5--Turn-Signal Sign. The turn-signal signs, as indicated on the plans, shall conform to the applicable requirements of Section 630.

722.14.6--Tether Cable. Tether cable attached to the bottom of the signal head shall conform to the requirements of Subsection 722.04 and of the size shown on the plans. Tether cable clamps shall be designed such that the clamp will break away without damage to the signal head when the tether cable is hit by a vehicle.

722.14.7--Back Plate. Back plates shall be supplied when called for on the plans. Back plates shall be one-piece construction and meet the requirements of Subsection 722.14.1.5.

722.14.8--Traffic Signal Lamps. Traffic signal lamps shall meet the requirements of the latest revision of the Institute of Transportation Engineers (ITE) "Standard for Traffic Signal Lamps". Sizes shall be as follows:

<u>Head</u>	<u>Wattage</u>	<u>Light Center Length (L.C.L.)</u>	<u>Average Rated Hours</u>
12" Traffic Signal	150 at 130 Volts	3 inch	8000
Pedestrian Signal	67 at 130 Volts	2 7/16 inch	8000

722.14.9--LED Signal Modules. LED signal modules shall be sealed units comprised of an outer lens, an optical lens, a printed circuit board for LEDs, and entirely enclosed power supply, a back cover and a gasket.

The assembly and manufacturing process for the LED signal modules shall be designed to assure all internal LED and electronic components are adequately supported to withstand mechanical shock and vibration from high winds and other sources as per MIL-STD-883.

The LED signal module shall be rated for use in the ambient operating temperature range of -40°C to +74°C.

The LED signal module lens shall be UV stabilized.

The light distribution of each LED shall be maximized by an internal beam controlling optical faceted lens designed and patented to meet the 44 points measurement of the VTCSH standard, Part 2. The outer cover made of ultraviolet stabilized polycarbonate shall be convex with a smooth outer surface and be an integral part of the module.

The chip in the ultra-bright 1/5 inch LEDs shall be made using AlInGaP for red and amber, and InGaN technology for the green, and be rated for 100,000 hours of continuous operation by the LED manufacturer.

Enclosures containing either the power supply or electronic components of the signal module shall be made of UL94VO flame retardant materials.

The measured chromaticity coordinates of LED signal modules shall conform to the chromaticity requirements of Section 8.04 and Figure 1 of the VTCSH standard. The LED manufacturers indicate the following X-Y coordinates for their respective LEDs. The X value for red LEDs varies from 0.690 to 0.708 and the Y value varies from 0.292 to 0.306. The value X for amber LEDs varies from 0.554 to 0.575 and the Y value varies from 0.424 to 0.445. The X value for the green LEDs varies from 0.1090 to 0.1138 and the Y value varies from 0.5673 to 0.5830.

All wiring and terminal blocks shall meet the requirements of Section 13.02 of the VTCSH standard. Two secured, color coded, three feet long 600 V, 20 AWG minimum, jacketed wires, conforming to the National Electrical Code, rated for service at +105°C, are to be provided for electrical connection.

The module shall operate on a 60 Hz AC line voltage ranging from 80 volts rms to 135 volts rms with less than 10% light intensity variation. Nominal rated voltage for all measurements shall be 120 ± 3 volts rms. The circuitry shall prevent flickering over this voltage range.

The individual LEDs be wired so that a catastrophic failure of one LED will result in the loss of only that one LED, and not the entire string of LEDs or the entire module.

The power supply must permit the regulation of the current supplied to the LEDs to maintain a constant current.

The LED signal and associated on-board circuitry must meet Federal Communications Commission (FCC) Title 47, Sub-Part B, Section 15 regulations concerning the emission of electronic noise.

The LED signal module shall provide a power factor of 0.90 or greater at 25°C and at the nominal operating voltage.

Total harmonic distortion (THD), current and voltage, induced into an ac power line by a signal module shall not exceed 20 percent, over the operating voltage range specified in Section 14 and within the ambient temperature range specified in Section 4.

The signal module on-board circuitry shall include voltage surge protection to withstand high-repetition noise transients and low-repetition high-energy transients as stated in Section 2.1.6, NEMA Standard TS-2, 1992.

The LED signal module shall operate from a 60 ± 3 Hz ac line power over a voltage range from 80 VAC rms to 135 VAC rms. The current draw shall be sufficient to ensure compatibility and proper triggering and operation of load current switches and conflict monitors in signal controller units the procuring traffic authority customer has in use. Load switches shall be compatible with NEMA TS-1 or later, or Model 170-1989 or later.

All LED signal modules shall be energized for a minimum of 24 hours, at 100 percent on-time duty cycle, in an ambient temperature of 60°C .

Each socket shall be provided with one black lead from the socket and one white lead from the shell. Terminal blocks shall be a six position, twelve block, terminal barrier strip placed in the top or red section of all traffic signal heads. Terminal blocks shall be secured on both ends.

722.15--Traffic Signal and Equipment Support Poles. Type V, VI, and VII shall be welded or seamless $4\frac{1}{2}$ -inch O.D. steel pipe, ASTM Designation: A 53, 36 ksi minimum yield strength, galvanized in accordance with ASTM

Designation: A 123.

722.16--Mast Arms for Traffic Signal and Equipment Poles. Mast arms shafts shall be tapered and fabricated from a single sheet of not less than No. 7 MSG hot rolled, commercial quality, carbon steel with a single longitudinal automatically electrically welded joint. The taper shall be approximately 14/100 inch per foot. After forming and welding, the tapered shaft shall be longitudinally cold rolled under sufficient pressure to flatten the weld and increase the physical characteristics of the shaft so that the metal will have a minimum yield strength of 55,000 psi. A flange plate of one and one-quarter inch thickness shall telescope the large end of the arm and be welded by two continuous electric arc welds, one being on the outside of the plate, adjacent to the shaft, and the other one on the inside at the end of the tubular cross section.

This flange plate shall have four holes for one and one-quarter high strength bolts which will match the four tapped holes in the mounting plate on the pole. Mast arms shall be galvanized in accordance with the requirements of ASTM Designation: A 123.

Poles for mast arms shall meet the same requirements as Type I poles and in addition, a flange plate of one and one-quarter thickness for supporting the mast arm shall be welded to the pole near the top and supported with side plates tangent to the pole and gusset plates both top and bottom.

722.17--Pedestrian Pushbutton. Pushbutton shall consist of a direct push type button and single momentary contact switch. The housing shall be cast metal and shall be primed and painted Federal Yellow in color. The housing shall be raintight and weatherproof and shall protect users from electrical shock. The pushbutton shall be provided complete with suitable mounting hardware for banding, or attaching by other suitable methods, to poles.

722.18.--Vehicle Loop Assemblies.

722.18.1--Vehicle Loop Sealant.

722.18.1.1--General. Material shall be a polyurethane or rubberized-asphalt system conforming to the requirements herein. The system shall be manufactured specifically for this use and shall be used in accordance with the manufacturer's instructions. The system shall be dielectric, have no detrimental effect on cable insulation, and bond to either Portland cement or bituminous concrete paving with minimal shrinkage. The material shall, when cured, retain flexible characteristics and accommodate movement associated with Portland cement and bituminous concrete pavements. The material shall not track in hot weather and be suitable for applying when the surface temperature is between 50°F and 130°F.

The material shall be resistant to the effects of weather, vehicular abrasion, motor oils, gasoline, antifreeze solution, brake fluid, and deicing chemicals normally encountered.

722.18.1.2--Polyurethane System. The polyurethane sealant shall be a one-part elastomeric compound requiring no mixing or application of heat prior to or during installation. The sealant shall meet the following additional requirements:

<u>Property</u>	<u>Requirement</u>	<u>Test Procedure</u>
Hardness, Shore A	85 maximum	ASTM: D 2240
Tensile Strength, psi	500 minimum	ASTM: D 412
Elongation, %	250 minimum	ASTM: D 412
Adhesion in Peel, pounds/inch	10 minimum	ASTM: D 903
Track-Free Time, Polyethylene Film, hours	24 maximum	-
Shelf Life, months	6 minimum	-

722.18.1.3-Rubberized-Asphalt System. Rubberized-asphalt sealant shall be a two-component, self-leveling, cold-applied liquid sealant with no heating or thinning. The two components shall be mixed in accordance with the manufacturer's instructions. The sealant shall conform to the following additional requirements:

<u>Property</u>	<u>Requirement</u>	<u>Test Procedure</u>
Pot Life @ 77°F, minutes	25 minimum	-
Initial Cure Time @ 77°F, hours	1.0 maximum	-
Hardness, Shore A	20 maximum	ASTM: D 2240
Flow @ 140°F, 5 hours	No Flow	ASTM: D 5329
Bond @ 0°F, 3 cycles, minimum	50% of original width	ASTM: D 5329
Water Absorption, 72 hours, %	0.1 maximum	-
ASTM #3 Oil, Absorption, 24 hours, %	0.1 maximum	-

722.18.1.4--Acceptance Procedure. The Contractor shall furnish to the Engineer three copies of the manufacturer's certification for each lot of sealant, stating that the sealant meets the requirements of these specifications.

722.18.2--Loop Wire. Loop wire shall meet the requirements of Subsection 722.03.

722.18.3--Conduit. Conduit required for installation of the loop lead-ins shall be in accordance with Section 668.

722.18.4--Probe Point Detection Units. When the loop assembly consists of probe point detection units, the probe units shall be capable of operating in a temperature range of -35°F to 165°F and in 100% humidity. The probe shall not

be affected by water, snow, ice or pavement deterioration. The probe cable shall be polyurethane jacketed, polypropylene insulated less than 1/4 inch in diameter. Probes are to be located in a one-inch vertical hole approximately 18 inches below the roadway surface. Probe cable is to be installed in 1/4-inch saw cut slot made by a diamond or abrasive power saw.

722.19--Loop Detector Amplifier Units.

722.19.1--General. These units shall be designed to operate on 115 volts, 60 Hz alternating current.

The unit shall be fully operable under voltage ranging from 100 to 134 volts and temperature ranging from -30°F to +165°F and shall not be affected by environmental conditions, altitude or positioning.

722.19.1.1--Stand Alone Units. The unit shall be of digital, solid state construction with printed circuit boards laminated from high quality glass-epoxy materials. Connections shall be made through a 10 pin MS type connector for the single channel and two channel units and a 19 pin MS connector for four channel units.

A dust resistant enclosure suitably protected against corrosion and accidental damage to field wiring shall be provided to enclose all electrical parts of the unit.

722.19.1.2--Card Rack Mounted Units. A card rack assembly shall consist of three main components, the card rack, power supply module(s) and loop detector amplifier module(s). A second power supply is required when more than four amplifier modules are required.

The card rack shall be manufactured from aluminum and designed to accommodate three through eight, two-inch wide modules. The card rack shall include universal mounting brackets for either side or rear wall or shelf mounting.

Each of the four outputs of the power module will power a plug-in magnetometer or digital loop detector module. Each output shall have a separate fuse and LED indicator light mounted on the front panel.

The loop detector amplifier module(s) shall be a digital, inductive loop detector amplifier with digital output timings.

722.19.2--Specific Requirements. The detector shall be capable of operating loop and lead-in systems with minimum composite inductance ranges from 50 to 1400 microhenries with maximum sensitivity capable of detecting 0.02 percent inductance changes.

722.19.3--Features and Operational Requirements. The unit shall have the following minimum features and operational requirements.

722.19.3.1--Fully Self-Tuning. The unit shall tune automatically upon the application of power. It shall achieve normal operation and at least 90% of its selected sensitivity within 30 seconds after application of power.

722.19.3.2--Modes of Operation. Each channel shall be capable of functioning in the following two front panel selectable modes:

- (a) Presence - When in this mode, the detector channel shall be capable of detecting the presence of a large motorcycle located in a conventional 6-foot x 6-foot, 3-turn loop, and holding the call for at least four minutes.
- (b) Pulse - A detection output between 75 and 150 milliseconds shall be initiated when a vehicle enters the zone of detection. If a vehicle remains in the zone of detection, the detector shall become responsive within a maximum of 30 seconds to additional vehicles entering the loop.

722.19.3.3--Sensitivity Switches. Each channel of the detector shall include means to select at least seven (7) levels of sensitivity up to a maximum sensitivity of at least 0.02 percent change in inductance.

722.19.3.4--Frequency Separation. The unit shall be capable of preventing cross-talk between channels of the same unit by sequential scanning of the various channels, and between separate units by means of a front panel mounted frequency control switch.

722.19.3.5--Output. Relay, N.O. and N.C. contacts. The relay shall furnish a continuous call in case of power failure, detector failure or an open loop.

722.19.3.6--Detection Indication. A long life LED or incandescent indicator shall be provided for each channel to give a visual indication of each vehicle detection.

722.19.3.7--Automatic Drift Compensation. The detector unit shall automatically accommodate those after-turning changes in the loop as might reasonably occur in undamaged loops, properly installed in sound pavement without producing a false output or change in sensitivity.

722.19.3.8--Detection of Continuous Traffic Queues. Each channel shall provide unlimited detection of continuous traffic without loss of detection in long peak-hour traffic queues. Vehicle movement over the loop shall re-start presence hold time.

722.19.3.9--Built-in Noise Rejection Circuitry. The detector electronics shall be adequately protected from transient voltages and currents which may occur on

both power lines and loop leads.

722.19.3.10--Write on Pads. A write on pad for each channel shall be provided on the front of the unit in order to label each channel.

722.19.3.11--Delay and Extension Timing. When called for in the plans, the detector shall contain the necessary electronics to provide both delayed call and extended call operation. Timing shall be digital and selection of delayed, extension or normal detector operation shall be accomplished via front panel control.

- (a) Delay timing shall inhibit detector output until presence has been maintained for the time selected. Each new detection shall restart the delay time. Timing adjustment shall be from 0 to 31 seconds in one-second increments. The detector shall be capable of disabling delay timing by external means during that detector's associated green phase. External input may be either ground active DC or line voltage AC active.
- (b) Extension timing shall hold detector output for the period of time selected after the vehicle leaves the loop. Timing adjustments shall be from 0 to 7.75 seconds in 0.25-second increments. The detector shall be capable of disabling extension timing by external means during that detector's associated red phase. External input may be the absence of either ground active DC or line voltage AC active.

722.19.3.12--Surge Protection. Each detector input circuit shall be equipped with a three terminal surge protection device capable of protecting the detector amplifier against differential mode surges and common mode surges. The unit must withstand six 400 Amp (8 x 20 μ s) differential mode surges and six 1000 Amp (8 x 20 μ s) common mode surges. The unit shall clamp these surges at 35 volts maximum in less than 40 nanoseconds. Differential capacitance shall be less than 50 picofarads. The unit shall be epoxy encapsulated.

722.20--Infrared Vehicle Detector Units. Infrared vehicle detector units shall operate on 115 volt A.C. or 24 volt D.C. current under temperature ranges of -40°F to 150°F.

Output shall be by fail safe, change over heavy duty relays, contacts rated at 60 VA, 2A, 250 V, or optically isolated solid state, with hold off voltage of 35 DC on voltage <1.5V at 50mA. Outputs shall be inhibited for one (1) second after detection has occurred.

Vehicle detection shall be indicated by illuminating a high intensity LED.

Units are to be capable of detecting moving vehicles within a zone of detection up to 300 feet from unit.

Units shall be housed in a weatherproof, dust-resistant enclosure for suitable side of pole mounting and appropriate adjustments for proper positioning. Positioning shall be accomplished by using a sighting hood placed on top of the housing.

The unit shall carry a minimum two-year manufacturer's warranty.

Surge protection required in the controller cabinet capable of protecting the controller cabinet from differential mode and common mode surges.

722.21--Fiber Optic Cable.

722.21.1--Fiber Characteristics. All fibers in the cable must be usable fibers and meet required specifications.

Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding. The fiber shall be matched clad design.

MULTIMODE: The multimode fiber utilized in the cable specified herein shall meet EIA/TIA-492AAAA-1989, "Detail Specification for 62.5 μm Core Diameter/125 μm Cladding Diameter Class Ia Multimode, Graded Index Optical Waveguide Fibers."

Core diameter:	62.5 \pm 3.0 μm
Cladding diameter:	125.0 \pm 2.0 μm
Core-to-Cladding	Offset: 3.0 μm
Cladding non-circularity:	2.0% Defined as: $[1 - (\text{min. cladding dia.} \div \text{max. cladding dia.})] \times 100$
Core non-circularity:	5.0% Defined as: $[1 - (\text{min. core dia.} \div \text{max. core dia.})] \times 100$
Coating Diameter:	245 \pm 10 μm
Colored Fiber Diameter:	nominal 250 μm
Attenuation Uniformity:	No point discontinuity greater than 0.20 dB at either 850 nm or 1300 nm
Refractive Index Profile:	Graded index
Numerical Aperture:	0.275 \pm 0.015

SINGLE-MODE: The single-mode fiber utilized in the cable specified herein shall conform to the following specifications:

Typical Core Diameter:	8.3 μm
Cladding Diameter:	125.0 \pm 1.0 μm
Core-to-Cladding Offset:	0.8 m
Cladding Non-Circularity:	1.0%

	Defined as: $[1 - (\text{min. cladding dia.} \div \text{max. cladding dia.})] \times 100$
Coating Diameter:	$245 \pm 10 \mu\text{m}$
Colored Fiber Diameter:	nominal 250 μm
Attenuation Uniformity:	No point discontinuity greater than 0.10 dB at either 1310 nm or 1550 nm
Attenuation at the Water Peak:	The attenuation at $1383 \pm 3 \text{ nm}$ shall not exceed 2.1 dB/km
Cutoff Wavelength:	The cabled fiber cutoff wavelength (λ_{ccf}) shall be $< 1250 \text{ nm}$
Mode-Field Diameter:	$9.30 \pm 0.50 \mu\text{m}$ at 1310 nm $10.50 \pm 1.00 \mu\text{m}$ at 1550 nm
Zero Dispersion Wavelength (λ_0):	$1301.5 \text{ nm} \text{ } _0 1321.5 \text{ nm}$
Zero Dispersion Slope (S_0):	$0.092 \text{ ps}/(\text{nm}^2 \text{ km})$
Polarization Mode Dispersion:	$0.5 \text{ ps}/\text{rt}^2 \text{ km}$

The coating shall be a dual-layered, LTV-cured acrylate applied by the fiber manufacturer.

The coating shall be mechanically strippable without damaging the fiber.

722.21.2--Fiber Specification Parameters. The Maximum Individual Fiber Attenuation for multimode fibers shall be 3.5dB/km @ 850 nm, 1.0 dB/km @ 1300 nm. The Maximum Individual Fiber Attenuation for single-mode fibers shall be 0.40dB/km @ 1310 nm, 0.30 dB/km @ 1550 nm.

For multimode use, the minimum normalized bandwidth of multimode optical fibers shall be 160 MHz_km at 850 nm and 500 MHz_km at 1300 nm.

For single-mode use, the maximum dispersion shall be 3.2 ps/(nm_km) from 1285 nm through 1330 nm and shall be 17 ps/(nm_km) at 1550 nm.

722.21.3--Outdoor Trunk Cables. Optical fibers shall be placed inside a loose buffer tube. The nominal outer diameter of the buffer tube shall be 1/8 inch. Each buffer tube shall contain up to 12 fibers. The fibers shall not adhere to the inside of the buffer tube.

Each fiber shall be distinguishable from others by means of color coding in accordance with EIA/TIA-598-A, "Optical Fiber Cable Color Coding". The ink for coloring fibers shall be UV cured, no thermal inks shall be used in the coloring process. Buffer tubes containing fibers shall also be color coded with distinct and recognizable colors in accordance with EIA/TIA-598, "Optical Fiber Cable Color Coding". Buffer tube colored stripes shall be inlaid in the tube by means of co-extrusion when required. The nominal stripe width shall be one mm.

For dual layer buffer tube construction cables, standard colors are used for tubes 1 through 12 and stripes are used to denote tubes 13 through 24. The color sequence applies to tubes containing fibers only, and shall begin with the first tube. If fillers are required, they shall be placed in the inner layer of the cable. The tube color sequence shall start from the inside layer and progress outward.

In buffer tubes containing multiple fibers, the colors shall be stable during temperature cycling and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.

The buffer tubes shall be resistant to external forces and shall meet the buffer tube cold bend and shrinkback requirements of 7 CFR 1755.900.

Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.

The central anti-buckling member shall consist of a glass reinforced plastic rod. The purpose of the central member is to prevent buckling of the cable.

Each buffer tube shall be filled with a non-hygrosopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.

Buffer tubes shall be stranded around the dielectric central member using the reverse oscillation, or "SZ", stranding process. Water blocking yarn(s) shall be applied longitudinally along the central member during stranding.

For single layer cables, a water blocking tape shall be applied longitudinally around the outside of the stranded tubes/fillers. The tape shall be held in place by a single polyester binder yam. The water blocking tape shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt and foreign matter. Dual layer cables shall be water blocked in a similar fashion.

Two polyester yam binders shall be applied contrahelically with sufficient tension to secure the buffer tube layer to the central member without crushing the buffer tubes. The binders shall be non-hygrosopic, non-wicking and dielectric with low shrinkage.

The cable shall contain at least one ripcord under the sheath for easy sheath removal.

Tensile strength shall be provided by high tensile strength aramid yams and/or fiberglass yams.

The high tensile strength aramid yams and/or fiberglass yams shall be helically stranded evenly around the cable core.

The cable shall be sheathed with medium density polyethylene. The minimum nominal jacket thickness shall be 0.055 inch. Jacketing material shall be applied directly over the tensile strength members and water blocking tape. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.

The jacket or sheath shall be free of holes, splits, and blisters. The cable jacket shall contain no metal elements and shall be of a consistent thickness. The cable jacket shall be marked with "Manufacturer's Optical Cable" sequential foot markings, year of manufacture. The actual length of the cable shall be within -0/+1% of the length markings. The marking shall be in contrasting color to the cable jacket. The height of the marking shall be approximately 0.10 inch.

The maximum pulling tension shall be 608 lbf during installation, short term, and 200 lbf long term installed.

The shipping, storage, and operating temperature range of the cable shall be -40°F to +160°F. The installation temperature range of the cable shall be -20°F to +160°F.

722.21.4--Drop Cable to Controllers, VMS, Camera Locations. Optical fibers shall be placed inside a single loose buffer tube. The buffer tube shall contain up to 12 fibers. The fibers shall not adhere to the inside of the buffer tube. Each fiber shall be distinguishable from others.

The colors shall be stable during temperature cycling and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.

The buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.

The cable core interstices shall be filled with a water-blocking compound or water blocking strength members. The compound, if used in the design shall be a thixotropic gel containing a Super Absorbent Polymer (SAP) material. The gel shall be non-nutritive to fungus, electrically non-conductive and homogenous. The gel shall be free from dirt and foreign matter and shall be readily removable with conventional nontoxic solvents.

The cable shall contain at least one ripcord under the sheath for easy sheath removal. Tensile strength shall be provided by high tensile strength yams. The

high tensile strength yarns shall be helically stranded evenly around the central tube.

The cable shall be sheathed with UV resistant jacketing compound. The minimum nominal jacket thickness shall be 0.055 inch. Jacketing material shall be applied directly over the tensile strength members and water blocking compound. The jacketing material shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus. The jacket or sheath shall be free of holes, splits, and blisters.

The cable jacket shall contain no metal elements and shall be of a consistent thickness. The maximum diameter of the cable shall not exceed 0.39 inch. The cable jacket shall be marked with "'Manufacturer' Optical Cable", sequential foot markings, year of manufacture. The actual length of the cable shall be within -0/+1% of the length markings. The marking shall be in contrasting color to the cable jacket. The height of the marking shall be approximately 0.10 inch.

The maximum pulling tension shall be a minimum of 300 lbf during installation, short term, and 115 lbf long term installed.

The shipping, storage, and operating temperature range of the cable shall be -40°F to +160°F. The installation temperature range of the cable shall be -20°F to +160°F.

722.21.5--General Cable Performance Specifications for OSP Cables. When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber Optic Components", the change in attenuation at extreme operational temperatures of -40°F to +160°F shall not exceed 0.2 dB/km at 1550 nm for single-mode fiber and 0.5dB/km at 1300 nm for multimode fiber.

When tested in accordance with FOTP-82, "Fluid Penetration Test for Filled Fiber Optic Cable", a one-meter length of unaged cable shall withstand a one meter static head or equivalent continuous pressure of water for one hour without leakage through the open cable end.

When tested in accordance with FOTP-81, "Compound Flow (Drip) Test for Filled Fiber Optic Cable", the cable shall exhibit no flow (drip or leak) of filling or flooding compound at 150°F.

When tested in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cables", the cable shall withstand a minimum compressive load of 125 lbf/in applied uniformly over the length of sample. The load shall be applied at the rate of 1/8 inch to 3/4 inch per minute and maintained for 10 minutes. The change in attenuation shall not exceed 0.4 dB during loading and 0.2 dB after loading at 1550 nm for single-mode fiber and 1.0 dB during loading and 0.4 dB

after loading at 1300 nm for multimode fiber.

When tested in accordance with FOTP-104, "Fiber Optic Cable Cyclic Flexing Test", the cable shall withstand 25 mechanical flexing cycles around a sheave diameter not greater than 20 times the cable diameter. The change in attenuation shall not exceed 0.1 dB at 1550 nm for single-mode fiber and 0.3 dB at 1300 nm for multimode fiber.

When tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies," the cable shall withstand 25 impact cycles. The change in attenuation shall not exceed 0.2 dB at 1550 nm for single-mode fiber and 0.3 dB at 1300 nm for multimode fiber.

When tested in accordance with FOTP-33, "Fiber Optic Cable Tensile Loading and Bending Test", using a maximum mandrel and sheave diameter of 22 inches, the cable shall withstand a tensile load of 608 lbf. The change in attenuation shall not exceed 0.2 dB during loading and 0.1 dB after loading at 1550 nm for single-mode fiber and 0.5 dB during loading and 0.2 dB after loading at 1300 nm for multimode fiber.

When tested in accordance with FOTP-85, "Fiber Optic Cable Twist Test", a length of cable no greater than 12.5 feet will withstand 10 cycles of mechanical twisting. The change in attenuation shall not exceed 0.1 dB at 1550 nm for single-mode fiber and 0.2 dB at 1300 nm for multimode fiber.

When tested in accordance with FOTP-37, "Low or High Temperature Bend Test for Fiber Optic Cable", the cable shall withstand four full turns around a mandrel of 10 times the cable diameter after conditioning for four hours at test temperatures of -20°F and +140°F. Neither the inner or outer surfaces of the jacket shall exhibit visible cracks, splits, tears or other openings. Optical continuity shall be maintained throughout the test.

722.21.6--Quality Assurance Provisions. All optical fibers shall be proof tested by the fiber manufacturer at a minimum load of 100 kpsi. All optical fibers >3000 feet shall be 100% attenuation tested. The attenuation of each fiber at both operational windows shall be provided with each cable reel. The cable manufacturer shall be ISO 9001 registered.

722.21.7--Packaging. The completed cable shall be packaged for shipment on nonreturnable wooden reels. Top and bottom ends of the cable shall be available for testing. Both ends of the cable shall be sealed to prevent the ingress of moisture. Each reel shall have a weather proof reel tag attached identifying the reel and cable.

722.22--Multi-Channel Video Multiplexer.

722.22.1--Features. The multi-channel video multiplexer shall have the following features.

- 8-Bit Digitally-Encoded Video Transmission Transmits up to 16 Real-Time Color Video Signals on One Optical Fiber.
- Meet or exceed all requirements for RS-250C Medium Hall Transmission.
- Exceptionally Low Video Distortion with Zero Performance Variation vs. Optical Path Loss.
- Ideally Suited to Networks Requiring Multiple Physical Layers Where Video Degradation May be a Problem.
- Be directly Compatible with All NTSC, PAL, or SECAM CCTV Camera Systems.
- Wide Optical Dynamic Range.
- Meet or exceed NEMA TS-1/TS-2 and Caltrans Traffic Signal Control Equipment Environmental Specifications for Operating temperature, Shock, Vibration, Humidity and Voltage Transient Protection.
- Ensure Extremely High Reliability in Unconditioned Out-of-Plant Environments.
- Provide LED Status Indicators.
- Provide Solid-State Current Limiters.
- Lifetime Warranty.

722.22.2--Specifications. The multi-channel video multiplexer shall have the following specification requirements.

VIDEO

Video Input	1 volt peak to peak @ 75 ohms
Input and Output Channels	4, 8, 12 or 16
Bandwidth	5 Hz to 6.5 MHz
Differential Gain	<2%
Differential Phase	<0.7%
Tilt	<1%
Signal-to-Noise Ratio (SNR)	60 dB @ Maximum Optical Loss Budget

ELECTRICAL & MECHANICAL

Power	115-230 VAC, 50/60 Hz, 10 Watts
Current Protection	Automatic Resettable Solid-State Current Limiters
Circuit Board	Meets IPC Standard

ENVIRONMENTAL

MTBF	>100,000 hours
Operating Temp	-40° C to +74° C
Storage Temp	-40° C to +85° C
Relative Humidity	0% to 95%, non-condensing

OPTICAL EMITTER:	Laser Diode
WAVELENGTH:	1300/1550 nm
NUMBER OF FIBERS:	1

LED INDICATIONS

Multiplexer Unit:

1. Video Input Sync Presence for Each Video Channel
2. Operating Power

Demultiplexer Unit:

1. Video Output Sync Presence for Each Video Channel
2. Optical Carrier Detect/Link-Lock
3. Operating Power
4. Video Sync Presence for Each Channel

**SECTION 723 - MATERIALS FOR ROADWAY LIGHTING
INSTALLATION**

723.01--General. Acceptance of all material in this Section is subject to Subsections 106.01 and 106.04 entitled "Source of Supply and Quality Requirements" and "Certification of Compliance", respectively.

723.02--Secondary Distribution.

723.02.1--Raceways, Conduit and Fittings. All branch circuits shall be in Schedule 40 polyvinyl chloride (PVC) or high-density polyethylene (HDPE) conduit unless specifically shown or noted otherwise on the plans, or stated otherwise in these specifications. Conduit exposed on service poles and within five (5) feet of any pole foundation or terminating point shall be galvanized rigid (GRC) heavy wall conduit.

Under roadways, or where conduit is jacked or bored, use Schedule 80 PVC or HDPE conduit.

When transitioning between differing types of conduit, the correct coupling must be used; i.e. GRC to PVC, PVC to HDPE, etc. These couplings shall be approved prior to their use on the project.

In outdoor structure mounted exposed locations, except as noted on the plans, galvanized or sherardized rigid steel conduit shall be used.

At underground entrance or exit locations, all rigid metal conduits in contact with earth shall be polyvinyl, polyethylene, or asphalt paint coated with three (3) coats, unless shown otherwise on the plans.

723.02.2--Conductors. Conductors shall be standard annealed copper rated 600 volts with mechanical strength, insulation, and current carrying capacity adequate for the particular conditions under which they are used and in accordance with the following schedule:

In all locations, types "THW" or "THWN" shall be used unless indicated otherwise on the plans and/or in the specifications.

In unwired fixtures where required by National Electrical Code (NEC), approved heat resistant wire shall be used. This wire shall be sized for current, voltage, and temperature at which fixture operates and in accordance with the latest edition of the NEC.

All conductors entering the self-contained ballast compartment of gaseous vapor discharge fixtures shall be rated 600 volts, silicone rubber, fixture wire, #10 AWG, stranded copper conductor, silicone rubber insulation, glass braid, rated conductor temperature of 200°C.

Wire sized #8 AWG and larger consisting of the stranded type shall have Class B stranding. Wire sized #10 AWG and smaller shall be of the solid type.

The minimum wire size allowed on any project, with exceptions as noted on the plans or as stated in the specifications, will be #12 AWG.

723.02.3--Pull Boxes and Junction Boxes. Pull boxes shall be of the types specified on the plans. The number and location of pull boxes shall comply with the requirements of the NEC. Pull boxes shall be used to limit the strain while pulling conductors and splices will not be allowed.

Junction boxes will of the type specified on the plans. Splices will be allowed in junction boxes. Junction boxes shall comply with the applicable requirements of the NEC. All items required by codes, such as grounds, ground rods, etc., shall be supplied and installed as part of the box and will be included as part of the cost of the box.

Ground mounted boxes shall have tops that are reinforced and rated H-20 for vehicular traffic.

Where shown on the plans a concrete collar or pad shall be constructed around the box. The dimensions of the concrete shall be specified in the plans. When the box falls on a slope it, and the pad, will be constructed to conform to the

contours of the slope. Site grading and other items will be included in the cost of the box.

723.03--Secondary Power Controller.

723.03.1--Lighting Controller. The lighting controller shall be factory assembled and contain the following items: one contactor, one hand-off-automatic selector switch, fused control circuit transformer, lightning arrestor, branch circuit breakers, a NEMA 3R enclosure, one photoelectric control and a main breaker. Details and schedules are shown on the plans. All breakers shall be labeled as to circuit served with a phenolic engraved label having 1/4-inch white letters on a black background.

723.03.1.1--Contactor. The contactor shall have a continuously rated 120-volt coil which is encapsulated. The contactor shall switch a load at 480 volts and shall have a minimum of 2 poles rated as per the plans. Auxiliary arcing contacts are not permitted. Power contacts shall be totally enclosed and of silver-cadmium-oxide. The contactor shall be in accordance with U.L. 508 and NEMA ICS 2, and rated for 600 volts maximum.

723.03.1.2--Main Breaker. The main breaker shall be a molded case circuit breaker rated at the amperage shown on the plans. Interrupting ratings shall be 22,000 amperes R.M.S. symmetrical. The breaker shall have an over-center trip-free toggle type operating mechanism with quick-make, quick-break action and the switch is "ON" "OFF". The breaker handle shall assume a center position when tripped, with a provision for mechanically tripping the breaker built into the cover. The breaker shall be calibrated for operation at 40°C.

723.03.1.3--Hand-Off-Automatic Selector Switch. The H-O-A switch shall be a heavy duty, three position, maintained contact selector switch with ratings as follows:

7200 VA make
720 VA break
120 - 600 V.A.C.

723.03.1.4--Control Transformer. Control transformer shall have a 480 volt primary and 120 volt secondary, with a fused secondary. The volt-ampere rating shall be a minimum of 500 VA above contactor requirements for other loads.

723.03.1.5--Lightning Arrestor. Arrestor shall be a low impulse spark over and high discharge - current capacity type.

723.03.1.6--Branch Circuit Breakers. Branch circuit breakers shall be molded case breakers, U.L. listed and shall meet NEMA Standard No. ABI-1975, and Federal Specification No. W-C-375B/GEN. The amperage ratings shall be as

scheduled on the plans. Interrupting ratings shall be 22,000 amps RMS symmetrical.

Breakers shall have over-center, trip-free, toggle-type operating mechanisms with quick-make, quick-break action and positive handle indication. All 2-pole breakers shall be common trip. Each breaker shall have a permanent trip unit containing individual thermal and magnetic trip elements in each pole. Circuit breaker handles shall assume a center position when tripped, with a provision for mechanically tripping the breaker built into the cover. Breakers shall be calibrated for operation in an ambient temperature of 40°C.

Breaker lugs shall be removable U.L. listed for copper only, and U.L. listed for installation of mechanical screw type lugs.

723.03.1.7--Copper Busing. Busing shall be copper with tin plating. Rating shall be 100 ampere or 200 ampere as scheduled on the plans.

723.03.1.8--Enclosure. The enclosure shall be NEMA 3R of minimum #14 gauge steel with a hinged door. One (1) hasp with padlock and a minimum of two (2) bolts to secure top and bottom of door shall be provided. Three (3) sets of keys shall be provided with each padlock.

723.03.2--Conduit. All conduit and fittings shall be rigid galvanized steel, sized as per plans or NEC.

723.03.3--Ground Rods. All ground rods shall be copper-coated steel 3/4-in by 10 feet installed as shown on plans. Ground wire connections shall be with exothermic welds.

723.03.4--Photocells. Photocell shall have a dust and watertight housing, and shall be rated for 120 volt operation. Contacts shall be rated at 1800 V.A. A time delay of a minimum of 15 seconds shall be built-in to prevent false switching. Turn-on shall be at approximately 1 to 3 foot-candles. Turn-off shall be at 1.5 to 9 foot-candles. Operational temperature range shall be -50 to +60°C. Failsafe protection is required in the closed position.

Mounting shall be as per plans. Built-in surge protection shall provide a margin of protection of 60°C spark over -1500 V RMS. Impulse spark over voltage discharge is 10,000 amperes, 1½ x 40 M.S. wave at 2000 volts.

Where required on plans that a photocell control Federal Aviation Administration (FAA) obstruction lights that photocell shall meet current FAA requirements.

723.03.5--Miscellaneous Hardware. All miscellaneous hardware shall be galvanized per ASTM Designation: A123.

Care shall be taken to reduce corrosion as much as possible. After drilling or cutting of parts or any operation that may damage anti-corrosion paint or coatings, the Contractor shall clean and apply anti-corrosion paint or coating. This shall be done at no additional cost to the Department.

723.03.6--Service Poles. Service poles shall be Southern Yellow Pine meeting the requirements of the latest edition of ANSI-05.1, "American National Standard for Wood Poles - Specifications and Dimensions", for Southern pine poles having a fiber stress of 8,000 psi. The poles shall be free of all defects such as holes, splits, sap rot, etc. Maximum deviation from straight poles shall be 1/2 inch for each six foot of length from surface of ground to top of pole when a string is stretched along its bow. Poles shall be approximately thirty (30) feet in length.

All poles shall be inspected and treated in accordance with applicable requirements of the American Wood-Preservers' Association (AWPA) and shall conform to Subsection 718.03 of the Standard Specifications.

723.03.7--Wiring. Wiring shall be copper conductors with THWN or THW type insulation. All wiring shall be tie wrapped and neatly trained in the enclosure.

723.04--High Mast Lighting Assembly.

723.04.1--Pole. The pole shall consist of sections of round or multi-sided tapered steel tubes which telescope together. Minimum yield strength after fabrication shall be 55,000 psi. Designed wind velocity shall be 100 MPH with a 1.3 gust factor to support the number and type luminaires and lowering device required on the different assembly types.

The pole shall be of ASTM Designation: A 572 or A 595, Grade 60 steel, hot dipped galvanized in accordance with ASTM Designation: A 123.

All factory welds shall be in accordance with ANSI/AWS Structural Welding Code D1.1 sections 1-8, and AASHTO requirements.

The pole shall have a minimum 10-inch wide by 20-in high oval handhole. The opening shall be reinforced to replace the equivalent strength lost by the hole. A hinged and gasketed handhole cover shall be provided, secured by four (4) stainless steel bolts, with three (3) hinges having stainless steel hinge pins. The cover shall be lockable with a hasp and a padlock provided and installed on each cover. The padlocks shall be keyed the same as the controller enclosures.

723.04.2--Lowering Device.

723.04.2.1--General. The lowering device shall be capable of lowering the luminaires to approximately five (5) feet from ground level for maintenance purposes. The lowering device shall consist of the following assemblies:

- (1) Head frame assembly
- (2) Luminaire mounting ring assembly
- (3) Winch assembly
- (4) Hoisting cable assembly

723.04.2.2--Head Frame Assembly. The head frame assembly shall be galvanized steel with a weather tight spun aluminum cover. A roller or pulley assembly shall be provided for power cord travel.

Three (3) positive latches shall be provided to support the luminaire ring when the lowering device is not in operation. Reflecting flags, visible from the ground, shall indicate the locking and unlocking of each of the latches. All moving parts of the latches shall be serviceable from the ground. Moving parts shall not be impaired by formation of ice. Latches shall be cast aluminum alloy conforming to ASTM Designations: B 221 or A 36 steel. Latch pins shall be ASTM A 276 stainless steel.

723.04.2.3--Luminaire Mounting Ring Assembly. The ring assembly shall be hot dipped galvanized steel channel, typically 6-inch by 2-inch, 7-gauge, with the proper number of 2-inch galvanized steel pipe luminaire mounting arms. The ring assembly shall be prewired with type ST distribution wiring, insulation rated at minimum 105°C. A cast aluminum or stainless steel, hinged cover, weather tight junction box shall be provided with a prewired 600-volt terminal block and a weatherproof twist lock power inlet, for testing of luminaires at ground level. This box shall be aligned with the access handhole cover.

The ring assembly shall be equipped with roller contact spring loaded guide arms to stabilize the ring on the pole while lowering device is in operation.

723.04.2.4--Winch Assembly. The winch shall be rated for 1500 pounds with a worm gear reduction minimum 30 to 1 ratio, and an integral friction drag brake to prevent free spooling. The winch shall be rated for intermittent motor operation or for hand crank operation. The 1/4-inch stainless steel hoisting cable shall be prewound on the winch. The winch drum shall be secured at both ends to prevent tilting.

723.04.2.5--Hoisting Cable Assembly. The hoisting cable shall be minimum 1/4-inch, 7 x 19 stainless steel. The three (3) suspension cables shall be minimum 3/16-inch stainless steel. The cable terminator shall be hot dipped galvanized.

Power cable shall be type SO and of a length and size as shown on plans.

723.04.3--Luminaire.

723.04.3.1--General. The luminaire shall be of the type and size as shown on the plans, normally an enclosed ventilated type with a one piece spun specular aluminum reflector, finished with an alzak or equivalent process. The reflector shall be encased in a spun and sealed aluminum cover or ribbed to provide additional structural integrity.

723.04.3.2--Ballast. The ballast shall be enclosed in a cast aluminum weather tight housing. Connections shall be made through a quick disconnect plug. The ballast shall be fused with inline fuses sized as per manufacturer's recommendations. The ballast shall be copper wound.

Electrical characteristics shall closely conform to the following:

Ballast Type	Lead
Primary Voltage	480V
Secondary Voltage (open circuit)	400V
Power Factor	over 90%
Input Watts	1100
Wattage Regulation	±12% at 10% line volt variation
Minimum Ambient Starting Temperature	20°F
Operating Line Current	2.35A

723.04.3.3--Mounting. The mounting shall be with an adjustable slipfitter for a 2-inch pipe bracket.

723.04.3.4--Lamp Socket. The lamp socket shall be heavy-duty, nickel-plated, porcelain enclosed with an integral lamp gripper and a lamp clamp of insulated stainless steel.

723.04.3.5--Photometrics. The luminaire shall provide an Illuminating Engineering Society (IES) Type V semi-cutoff distribution or as shown on the plans and shall have an output efficiency of 60% bare lamp lumens.

The lamp arc tube shall be optically shielded above 52° from the nadir. The maximum beam candle power for each 1000 lumens shall be a maximum of 200 at 80° vertical

Test reports with illumination data for each type distribution shall be provided with luminaire submittals. These reports must be certified, or conducted by an independent testing laboratory.

723.04.4--Anchor Bolts. Anchor bolts shall be steel in accordance with ASTM Designation: F 1554, Grade 105. Minimum yield strength shall be 105,000 psi. Galvanizing shall be in accordance with ASTM Designation: A 153. Anchor

bolts shall be of the sizes and number recommended and provided by the pole manufacturer.

Each pole shall have a bolt layout template provided by the pole manufacturer for proper bolt installation. The Contractor shall align the template properly for correct handhole orientation.

723.04.5--Lamps. Lamps for high mast luminaires shall be universal burning 1000-watt high pressure sodium. The lamp shall be mogul base and T-18 bulb designation. The lamp shall meet or exceed the following criteria:

Mean Lumens -----	126,000
Initial Lumens -----	140,000
Rated Average Life at 10 hr/start, hours -----	24,000

723.04.6--Miscellaneous. Ground rods shall be 3/4-inch by ten (10) feet, copper coated steel. Lightning rods, cable, bolts and other items making up the high mast lighting assembly shall be provided as per the plans and manufacturer's recommendations. All incidental items necessary for a complete working system shall be provided whether or not mentioned in these specifications.

723.05--Low Mast Lighting Assembly.

723.05.1--Poles. Poles shall be formed from a single sheet of hot rolled weldable grade steel, galvanized in accordance with ASTM Designation: A 123. Unless otherwise specified in the plans, the poles shall be forty (40) feet in length.

Unless otherwise noted on the plans, poles shall be made from steel meeting the requirements of ASTM Designation: A 572 Grade 55, or A 595 Grade A. Minimum yield strength shall be 48,000 psi after fabrication. Design wind loading shall be as indicated on the plans. The pole shall meet design wind loading with luminaires installed.

Poles shall have a mast arm as required and specified on the plans for luminaire mast arm mounting. Post top mounted luminaires will require a tenon mount.

Poles shall have a constant taper of 0.14 inch nominal per foot.

All poles shall be equipped with a breakaway device which conforms to the latest AASHTO and FHWA requirements, which have been approved by same. The Contractor shall submit a manufacturer's certification with the pole shop plans stating that the device meets, or exceeds, these standards.

Bridge-mounted poles shall be equipped with standard anchor bases for mounting on bridge brackets.

Poles shall have a 4-inch by 6½-inch handhole with bolted cover.

Arm lengths shall be as specified on the plans.

723.05.2--Luminaire. Low mast luminaires shall be post top mounted or mast arm mounted with 150-watt, 250-watt or 400 watt high pressure sodium lamps or as required on the plans.

The housing shall be die cast aluminum, joined with a lower housing by a stainless steel hinge, and provided with a trigger latch. The finish shall be gray baked-on enamel.

The reflector shall be polished anodic surface aluminum. The refractor shall be prismatic borosilicate glass. Photometrics shall conform to IES Type III, medium, semi-cutoff or as shown on the plans. Seals and gaskets shall be provided to prevent the entry of contaminants.

The ballast shall be prewired and closely conform to the following criteria:

	<u>400-watt</u>	<u>250-watt</u>	<u>150-watt</u>
Primary Voltage	480 V	480 V	480 V
Operating Current	1.0 A	0.63 A	0.42 A
Secondary Voltage, open circuit	215 V	222 V	128 V
Input Watts	458 W	295 W	188 W
Power Factor	Over 95%	Over 95%	Over 95%
Lamp Wattage Regulation @ ±10% Line Voltage Variation	+10%		
Minimum Ambient Starting Temperature	-20°F		

The ballast shall also have a quick disconnect. The slipfitter shall accept 1¼ to 2-inch outer diameter arms. Maximum projected area shall be 1.5 square feet.

723.05.3--Anchor Bolts. Anchor bolts shall be made of steel in accordance with ASTM Designation: F 1554, Grade 55. Anchor bolts shall be galvanized as per ASTM Designation: A 123. Minimum yield strength shall be 50,000 psi and "L" shaped. Anchor bolts shall be provided for each pole with two (2) hex nuts and washers per bolt. A bolt layout template shall be provided by the manufacturer for proper bolt installation. The number of anchor bolts and design yield strength shall be as recommended by the manufacturer.

723.05.4--Lamps. Lamps shall be clear 150-watt, 250-watt or 400-watt high pressure sodium type, which operate in any position. The lamps shall conform to the following:

	<u>150-watt</u>	<u>250-watt</u>	<u>400-watt</u>
Mean Lumens	14,000	27,500	45,000
Initial Lumens	16,000	24,750	50,000
Average Rated Life, hours	24,000	24,000	24,000

723.05.5--Miscellaneous. Wiring, ground rods, bolts and other items shall be provided as per the plans and manufacturer's recommendations. All items necessary for a complete working lighting assembly shall be provided whether or not mentioned in these specifications. Ground rods shall be 3/4-inch by ten (10) feet copper coated steel.

723.06--Underpass Lighting Assembly.

723.06.1--Housing. The lens shall be injection molded, U.V. stabilized polycarbonate. The reflector shall consist of a hydroformed specular alzak main reflector with parabolic and cylindrical surfaces. The unit shall produce a lighting pattern with a sharp cutoff at 86° above nadir.

Photometrics shall be IES, Type III, or as shown on the plans.

723.06.2--Ballast. The ballast shall be a high power factor type CWAA for 30°C starting and for a 150-watt, high pressure sodium lamp at 480 volts with double fusing.

723.06.3--Conduit Box. The conduit box shall consist of cast aluminum housing with gasketing, bolted to a flat aluminum plate.

723.06.4--Finish. The finish shall be a gray polyester powder coating which has been electrostatically applied and oven cured.

723.07--Portable Electric Power Unit.

723.07.1--General. The unit shall drive the winch through a torque limiter coupling to prevent excessive force on the system. A back-up shear pin shall be provided set for fifty six (56) pounds maximum. The unit used by the Contractor during construction will not be accepted. The power unit provided to the Department shall be new and unused except for testing to assure proper operation.

723.07.2--Housing. The housing shall be of cast aluminum.

723.07.3--Motor. The motor shall be heavy duty with high temperature windings. The rotor shall be dynamically balanced to assure vibration free operation. The motor shall operate at 120 volts AC, 60 hertz, with the proper horsepower to operate the lowering device recommended by the manufacturer.

723.07.4--Portable Transformer. The transformer shall be rated 480 volts primary and 120 volts secondary, rated KVA shall be 1.5 times necessary for the operation of the lowering device. The primary shall have a male weatherproof receptacle for acceptance of the pole power cord plug. The secondary shall have a weatherproof duplex receptacle, one (1) for connection of the power unit, and one (1) for other tools.

723.07.5--Remote Control Unit. The remote control unit shall have twenty (20) feet of remote cord, with a FORWARD, OFF, REVERSE switch. The switch operation shall be maintained contact type. Momentary contact spring load operation is not acceptable.

723.08--Temporary Lighting System.

723.08.1--Instructions. All exposed conduit shall be rigid galvanized steel. RTV silicon shall be used on all male threads. All final connections to light fixtures shall be through liquid-tight flexible conduits with weathertight connectors.

723.08.2--Conductors. All aerial conductors shall be triplex cable with an ACSR messenger. The conductor shall be aluminum with seven (7) strands. The messenger shall be the same size as the conductor with 6 to 1 stranding. The insulation shall be cross linked polyethylene, Type "XHHW-2" or "XLP".

Conduit installed conductors shall be type "THW" with standard annealed copper rated 600 volts.

Direct buried underground feeder or branch circuit shall be Type "UF".

All splices and connections shall be made in accessible boxes, switches, or at weatherheads.

Pressure type connectors shall be used. The connectors shall be well taped, rated for copper or aluminum

723.08.3--Lighting Assembly Requirements. All lighting assemblies shall be as shown on the plans. Fixtures shall be completely prewired with an integral photocell.

723.08.4--Lamps. Lamps shall be 250 or 400-watt clear high pressure sodium meeting or exceeding the following criteria:

Lamp Life at 10 hours per start, hours.....	24,000
Mean Lumens for 250-watt	27,000
for 400 watt.....	50,000
Burning Position	Operate in any position

723.08.5--Miscellaneous Material. Miscellaneous materials shall be furnished as shown on the plans, and as specified.

723.08.6--Timber Utility Poles. Timber utility poles shall be Southern Yellow Pine meeting the requirements of the latest edition of ANSI-05.1, "American National Standard for Wood Poles - Specifications and Dimensions", for Southern Pine poles having a fiber stress of 8,000 psi. The poles shall be free of all defects such as holes, splits, sap rot, etc. Maximum deviation from straight poles shall be 1/2" for each six (6) foot of length from surface of ground to top of pole when a string is stretched along its bow.

All poles shall be inspected and treated in accordance with applicable requirements of the American Wood-Preservers' Association (AWPA) and shall conform to Subsection 718.03 of the Standard Specifications.

723.08.7--Hardware. All hardware shall be approved for the use and location as shown on plans.

723.08.8--Safety Switch. All safety switches shall be General Duty 2-pole, 600-Volt, fused, with fuses sized as required, and in a NEMA 3R enclosure with a lock.

723.08.9--Junction Boxes. All junction boxes shall be cast aluminum. Locations of junction boxes will be as shown on plans.